LJ-00-09

SOUTHWEST FISHERIES SCIENCE CENTER

NATIONAL MARINE FISHERIES SERVICE - SOUTHWEST FISHERIES SCIENCE CENTER - P.O. BOX 271 LA JOLLA, CA 92038

**JULY 2000**

LIBRARY
Feb 7, 2001
2570 Dole Street

# EVASIVE BEHAVIOR OF EASTERN TROPICAL PACIFIC DOLPHINS RELATIVE TO RESEARCH VESSELS, 1986-90 AND 1998

by

Anne C. Allen, Sarah L. Mesnick, and Tim Gerrodette

ADMINISTRATIVE REPORT LJ-00-09

"This report is used to ensure prompt dissemination of preliminary results, interim reports, and special studies to the scientific community. The material is not ready for formal publication since the paper may later be published in a modified form to include more recent information or research results. Abstracting, citing, or reproduction of this information is not allowed. Contact author if additional information is required."

JULY 2000

# EVASIVE BEHAVIOR OF EASTERN TROPICAL PACIFIC DOLPHINS RELATIVE TO RESEARCH VESSELS, 1986-90 AND 1998

Anne C. Allen, Sarah L. Mesnick, and Tim Gerrodette

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, California, USA 92037

ADMINISTRATIVE REPORT LJ-00-09

Library
NOAA, National Marine Fisheries Service
SWFC Honolulu Laboratory F/SWC2
2570 Dole Street
Honolulu, HI 96822-2396

## ABSTRACT

The evasive behavior of five stocks of four species of eastern tropical Pacific dolphins (spotted, spinner, common, and striped dolphins) were analyzed relative to research vessels. Based on sightings during 6 cruises from 1986-90 and in 1998 in the area of the tuna purse-seine fishery, data were extracted and coded from the narrative description of each sighting. Analysis focused on behaviors that indicated evasive reactions to the research vessel. An evasive reaction was defined as behavior that included low swimming, school splitting, or frequent changes in direction as the boat approached. The majority of all dolphin stocks showed behavior that was evasive by our definitions. Among the dolphin stocks considered, striped dolphins were the most evasive, and mixed schools of offshore spotted and eastern spinner dolphins the least. There was a decrease in the frequency of evasive behavior between 1986-90 and 1998 for spotted, spinner, and common dolphins (species affected by the tuna purse-seine fishery), but not for striped dolphins (a species not involved in the fishery). Coastal schools of dolphins were less evasive than offshore schools. There was no obvious spatial pattern of evasive behavior associated with areas of high fishery effort.


## INTRODUCTION

By anecdotal accounts, the behavior of dolphins which are set on by the purse-seine fishery for tuna in the eastern tropical Pacific (ETP) has changed in response to the fishery. When the fishery expanded offshore during the 1970s, the previously unfished offshore schools of dolphins were said to be easier to chase and capture than schools nearer the coast. In subsequent years, tuna boats had to increase the number of chase boats needed to corral the dolphin schools. In an unpublished oral presentation, Stuntz and Perrin (1979) reported that the percentage of unsuccessful chases was positively related to fishing effort.

During the 1998 ETP line-transect survey conducted by the Southwest Fisheries Science Center, the scientific observers reported that dolphins were more evasive to the research vessels than a decade earlier in 1986-1990. This was a subjective judgment, because the behavior of dolphins was not quantitatively recorded.

Observers did, however, write a narrative account of each sighting. In this report, we (1) establish standardized terminology for describing the behavior of dolphins during ETP research cruises, (2) code the behaviors observed during research cruises using these definitions, and (3) summarize and compare behavior relative to the research vessels between the 1986-90 and 1998 periods. We focus on five stocks (management units) of four species: offshore spotted (*Stenella attenuata attenuata*, northeastern and western/southern stocks combined), eastern spinner (*S. longirostris orientalis*), whitebelly spinner (*S. l. longirostris/S. l. orientalis* hybrid), short-beaked common (*Delphinus delphis*) and striped (*S. coeruleoalba*) dolphins. Spotted and spinner dolphins are heavily involved in the tuna fishery. Common dolphins are involved but set upon less frequently. Striped dolphins are generally not set upon, although individuals may occasionally be killed by the fishery (National Research Council 1992).

## METHODS

We examined all on-effort[1] sightings of offshore spotted, eastern spinner, whitebelly spinner, short-beaked common and striped dolphins as well as mixed spotted-spinner schools during ETP

[1] "On-effort" refers to sightings of marine mammals that are recorded when a team of three observers is actively searching the area 180° forward of the ship while the ship is on the trackline moving at 10 knots.

cruises in 1986-90 and 1998. The Southwest Fisheries Science Center species codes used in this study are given in Table 1. The primary objective of the cruises was to conduct line-transect surveys in order to estimate abundance, but observers also wrote a narrative account of each sighting. Based on these narratives, we created a database with 32 fields (Table 2). The first 13 fields of each data record were part of the standard information collected with each sighting. Fields 14-32 were extracted from the narrative accounts of each sighting, and coded using standardized terms (Appendix 1). The standardized definitions were included in a new, expanded sighting form (NOAA Form 88-208, see Appendix 2), which was first used on the 1999 ETP cruise.

To summarize the data, we categorized each sighting in Field 31 as "evasive", "non-evasive", "both" or "no record," using the following definitions (see Appendix 1 for definitions of specific behaviors):

*Evasive.* An evasive sighting was defined as one that included one or more of the following behaviors: school splitting, low-swimming, or "other" evasive behavior, which included frequent changes of direction and general ship avoidance. If the dolphin school swam away as the ship approached, this was not sufficient to be called evasive.

*Non-evasive.* A non-evasive sighting was defined as one in which the dolphins approached the boat, or were observed bow-riding or wake-riding.

*Both.* A sighting that included behaviors from both of the previous two categories was considered to be both evasive and non-evasive. For example, the dolphins may approach the vessel, turn to run, and then split during the course of one sighting.

*No record.* When all behavior relative to the vessel (Fields 23-30) was unknown because of a lack of information, it was recorded as "no record."

We did not include running from the vessel as an indicator of evasive behavior because, although it is probably a ship-avoidance tactic, it was not an informative behavior due to the way running was recorded on these surveys. The distance at which dolphins began swimming away from the boat was rarely recorded. Since most dolphins are likely to move away from a large vessel approaching them, the mere note that dolphins swam away from the vessel at some point during the sighting did not indicate any particular evasiveness.

Evasive behaviors were summarized by stock, type of behavior, year, and location. Behaviors were plotted by geographic location using MapInfo Professional 4.0. Records without sufficient data to determine evasive behavior were not included in the calculation of the percentage of evasive sightings:

$$\% \text{ evasive sightings} = \frac{\text{\# of evasive sightings}}{(\text{total \# of sightings} - \text{\# of no records})} \times 100.$$

During 1986-1990 two vessels, the *David Starr Jordan* and *McArthur*, were used to collect data during each year. In 1998, an additional vessel, the *Endeavor*, was utilized, and there were more transects in coastal areas than had occurred previously (Kinzey *et al.*, 1999). Because behavior of coastal dolphins may have been different from that of offshore dolphins, we summarized the 1998 data both with and without the coastal transects. Coastal transects in 1998 included the following ships and dates (inclusive): *Jordan*: July 31 – Sep 12 (legs 1 and 2); *Jordan*: Nov 11 – Nov 16 (last part of leg 5); and *Endeavor*: Nov 20 – Nov 28 (first part of leg 5). We excluded these dates when comparing 1998 behavior to previous (1986-90) behavior.

## RESULTS

In total, 2,448 sightings were analyzed for all years, of which about one-fourth had insufficient data to determine evasive behavior (Table 3). Most sightings of all dolphin stocks were evasive by our definition. The stocks of dolphins exhibiting the highest percentages of evasive behavior were mixed schools of offshore spotted and whitebelly spinner dolphins (93.5%), striped dolphins (85.2%), and whitebelly spinner dolphins (85.1%). The dolphin stocks which are the main targets of the tuna fishery, offshore spotted and eastern spinner dolphins, displayed evasive behavior less frequently (64.2% and 63.8% of all sightings, respectively). Short-beaked common dolphins and mixed schools of offshore spotted and eastern spinner dolphins showed the least evasive behavior (57.2% and 52.1%, respectively).

There were similar patterns among dolphin stocks for the 1,835 sightings analyzed for the 1986-90 cruises (Table 4), the 613 sightings for the 1998 cruise using all transects (Table 5), and the 370 sightings in 1998 when coastal transects were excluded (Table 6). Evasive behavior for all stocks combined was 78.1% in 1986-90 (Table 4) and 63.4% in 1998 (Table 6). Table 5 shows an overall figure of 55.1% evasive behavior in 1998, but this lower figure was influenced by the higher proportion of coastal transects. The figures in Table 6 should be used to compare 1998 data to 1986-90 data in Table 4, as mentioned previously.

Table 7 summarizes the 1986-90 to 1998 comparisons across stocks. All dolphins except striped dolphins showed less frequent evasive behavior in 1998 than a decade earlier. The largest decrease in evasive behavior was for offshore spotted dolphins (decrease of 25.6%). The percentage of evasive striped dolphin behavior changed little between 1986-90 and 1998 (85.50% and 83.97%). Figures 1-5 show a breakdown of evasive behavior, by stock and year, into its constituents: school splitting, low swimming, and "other" (frequent changes of direction, etc.). The most common avoidance behavior for all stocks was running, although as mentioned earlier, this behavior may not be the best indicator of evasiveness. Low swimming appeared to be a more common evasive response than school splitting in offshore spotted and striped dolphins. For eastern spinner and short-beaked common dolphins, low swimming and school splitting were approximately equal in frequency. Whitebelly spinner dolphins stood out as having an especially high percentage of school splitting.

Over the period from 1986-90 to 1998, there was a drop in the number of evasive responses for every type of behavior and for every stock. The only exception to this was a slightly greater number of "other" records for short-beaked common and striped dolphins in 1998 than in some of the 1986-90 years. Between 1986-90 and 1998, there was an increase in the number of "no record" responses for every type of evasive behavior for every stock. Again, the only exception to this pattern was a smaller number of "no records" in 1998 for "other" evasive behaviors in short-beaked and striped dolphins. Overall, offshore spotted and spinner dolphins were similar in their behavior. The large number of mixed schools containing these two species may most easily explain this pattern.

Figures 6-28 show the overall evasive and non-evasive patterns of behavior plotted on geographic location. A clear onshore-offshore pattern was present across all stocks. Close-to-shore dolphin schools were more non-evasive, or both evasive and non-evasive in the same sighting. Offshore schools were more likely to be evasive. Striped and whitebelly spinner dolphins are not coastal stocks; therefore, the pattern was not as clear for them. Whitebelly spinner dolphin sightings in 1998 were not plotted, as there were only four sightings in total. For all years, the pattern of behavior for mixed-species schools of offshore spotted and eastern spinner dolphins looked very similar to the behavior pattern of pure offshore spotted schools. The behavior of offshore spotted and

whitebelly spinner mixed schools, however, mirrored that of pure whitebelly spinner dolphin schools. The effect of the tuna purse-seine fishery on evasive behavior, if any, was not evident in these plots. The patterns of evasive behavior of dolphins involved with the fishery (spotted, spinner, and common) did not appear to show either higher or lower amounts of evasiveness in the core area of the fishery than in areas of lower fishing effort.

In this report, we establish standardized terminology for describing the behavior of dolphins during ETP research cruises and code the narrative accounts of the observers into these categories. The behavior patterns summarized here should be interpreted with caution, because (1) the data were not part of an organized program of behavioral observations; (2) the narratives were qualitative, not quantitative, accounts of dolphin behavior; (3) certain important data, such as distance at which a behavior occurred, were not recorded; and (4) no statistical analyses have been applied to the data. Some specific evasive behaviors (e.g. school splitting and low swimming) may have evolved in response to changes in fishing intensity. In addition, behavior may be correlated with kill vs. set levels, environmental factors, or finer scale geographical or temporal variation in fishing intensity. In this study, striped dolphins served as a control, because this species does not associate with tuna and hence is only incidentally involved in the tuna fishery. That the percentage of evasive striped dolphin behavior changed little over this time supports the hypothesis that the decreases noted for other stocks are not due to some environmental factors nor to changes in the way observers recorded behavior. However, the increase in "no record" between 1986-90 and 1998 almost across the board may indicate something was different about the data gathering. During the 1999 and 2000 cruises, behavioral observations will be recorded on a form (Appendix 2), and dolphin behavior will also be recorded from the helicopter based on the *David Starr Jordan*.

## REFERENCES


Kinzey, D., T. Gerrodette, J. Barlow, A. Dizon, W. Perryman, P. Olson, and A. Von Saunder. 1999. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan* and the UNOLS ship *Endeavor*, July 31-December 9, 1998. NOAA-TM-NMFS-SWFSC-283, Southwest Fisheries Science Center, La Jolla, 113 pages.

National Research Council. 1992. Dolphins and the Tuna Industry. National Academy Press. Washington, D.C. 176 pages.

Stuntz, W. E., W. F. Perrin. 1979. Learned evasive behavior by dolphins involved in the eastern tropical Pacific tuna purse seine fishery. Abstract, Third Biennial Conference of the Biology of Marine Mammals, Oct. 7-11, 1979, Seattle, Washington.

Table 1. Dolphin species and stocks whose behavior was recorded and compared in the present study. Species codes are those used by the Southwest Fisheries Science Center.

| Species code | Scientific name | Common name |
|---|---|---|
| 2 | *Stenella attenuata attenuata* | Offshore spotted dolphin |
| 3 | *Stenella longirostris*, unid. subsp. | Unidentified spinner dolphin |
| 5 | *Delphinus* sp. | Unidentified common dolphin |
| 10 | *Stenella longirostris orientalis* | Eastern spinner dolphin |
| 11 | *Stenella l. longirostris/S. l. orientalis*, hybrid | Whitebelly spinner dolphin |
| 13 | *Stenella coeruleoalba* | Striped dolphin |
| 17 | *Delphinus delphis* | Short-beaked common dolphin |
| 90 | *Stenella attenuata*, unid. subsp. | Unidentified spotted dolphin |
| "200" | | Mixed schools of offshore spotted and eastern spinner dolphins |
| "300" | | Mixed schools of offshore spotted and whitebelly spinner dolphins |

Table 2. Database fields and codes. (* = add all codes that apply and record sum.)

| Field | Description | Code / value |
|---|---|---|
| 1 | Date | Date of sighting |
| 2 | Time | Time of sighting (local) |
| 3 | Sighting number | Sequential sighting number |
| 4 | Observer ID | Number of observer who made the initial sighting |
| 5 | Location | Latitude and longitude |
| 6 | Sea state | Beaufort scale |
| 7 | Species | Codes in Table 1 |
| 8 | School size | Mean of each observer's best estimate |
| 9 | Angle at sighting (degrees) | 999 = no record |
| 10 | Reticle at sighting | 999 = no record |
| 11 | Initial distance (naut. miles) | 999 = no record |
| 12 | Initial speed of school (knots) | 999 = no record |
| 13 | Direction relative to bow (degrees) | 999 = no record |
| 14 | Associated animals * | 1 = marine mammal, 2 = birds, 4 = tuna, 8 = no associations, 999 = no record |
| 15 | Presence of calves from form | 1 = yes, 2 = no, 999 = no record |
| 16 | Presence of calves from helo | 1 = yes, 2 = no, 999 = no record |
| 17 | Calibration school | 1 = yes, 2 = no, 999 = no record |
| 18 | Degree of aggregation | 1 = tightly aggregated, 2 = loosely aggregated, 999 = no record |
| 19 | Spacing | 1 = uniform, 2 = clumped, 999 = no record |
| 20 | Did distribution change during sighting? | 1 = yes, 2 = no, 999 = no record |
| 21 | Initial group behavior * | 1 = traveling, 2 = associated swimming, 4 = milling, 999 = no record |
| 22 | Individual behavior * | 1 = aerial activity, 2 = lob tailing, 4 = porpoising |
| 23 | Travel towards the boat (approach) | 1 = yes, 2 = no, 999 = no record |
| 24 | Bow riding | 1 = yes, 2 = no, 999 = no record |
| 25 | Travel away from the boat (running) | 1 = yes, 2 = no, 999 = no record |
| 26 | School splitting | 1 = yes, 2 = no, 999 = no record |
| 27 | Pattern of school splitting | 1 = starburst, 2 = clumped, 3 = not applicable, 999 = no record |
| 28 | Subgroup composition | 1 = single species, 2 = mixed-species, 3 = not applicable, 999 = no record |
| 29 | Low swimming | 1 = yes, 2 = no, 999 = no record |
| 30 | Other evasive behavior | 1 = yes, 2 = no, 999 = no record |
| 31 | Did this school exhibit evasive behavior? * | 1 = yes, 2 = no, 999 = no record |
| 32 | Comments | Any behavior that does not fit into one of the above fields |

Table 3. Percentage of evasive sightings by stock for MOPS (1986-1990) and SPAM (1998).

| Species Code | Common Name | Total # of Sightings | # of No Records | # of Sightings | # of Evasive Sightings | # of Non-Evasive Sightings | # of Both Ev. and Non-Ev. Sightings | % Purely Evasive Sightings |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 02 | Offshore spotted dolphin | 500 | 95 | 405 | 260 | 97 | 48 | 64.20% |
| 10 | Eastern spinner dolphin | 107 | 27 | 80 | 51 | 24 | 5 | 63.75% |
| 11 | Whitebelly spinner dolphin | 57 | 10 | 47 | 40 | 6 | 1 | 85.11% |
| 13 | Striped dolphin | 1049 | 304 | 745 | 635 | 95 | 15 | 85.23% |
| 17 | Short-beaked common dolphin | 343 | 100 | 243 | 139 | 78 | 26 | 57.20% |
| 200 | Mixed - offshore spotteds and easterns | 258 | 43 | 215 | 112 | 74 | 29 | 52.09% |
| 300 | Mixed - offshore spotteds and whitebellys | 134 | 27 | 107 | 100 | 7 | 0 | 93.46% |
| | | | | | | | | |
| | TOTAL | 2448 | 606 | 1842 | 1337 | 381 | 124 | 72.58% |

Table 4. Percentage of evasive sightings by stock for MOPS (1986-1990).

| Species Code | Common Name | Total # of Sightings | # of No Records | # of Sightings | # of Evasive Sightings | # of Non-Evasive Sightings | # of Both Ev. and Non-Ev. Sightings | % Purely Evasive Sightings |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 02 | Offshore spotted dolphin | 340 | 65 | 275 | 208 | 48 | 19 | 75.64% |
| 10 | Eastern spinner dolphin | 78 | 18 | 60 | 40 | 17 | 3 | 66.67% |
| 11 | Whitebelly spinner dolphin | 53 | 9 | 44 | 38 | 5 | 1 | 86.36% |
| 13 | Striped dolphin | 846 | 232 | 614 | 525 | 79 | 10 | 85.50% |
| 17 | Short-beaked common dolphin | 210 | 57 | 153 | 103 | 41 | 9 | 67.32% |
| 200 | Mixed - offshore spotteds and easterns | 187 | 30 | 157 | 88 | 49 | 20 | 56.05% |
| 300 | Mixed - offshore spotteds and whitebellys | 121 | 23 | 98 | 92 | 6 | 0 | 93.88% |
| | | | | | | | | |
| | TOTAL | 1835 | 434 | 1401 | 1094 | 245 | 62 | 78.09% |

Table 5. Percentage of evasive sightings by stock for SPAM (1998).

| Species Code | Common Name | Total # of Sightings | # of No Records | # of Sightings | # of Evasive Sightings | # of Non-Evasive Sightings | # of Both Ev. and Non-Ev. Sightings | % Purely Evasive Sightings |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 02 | Offshore spotted dolphin | 160 | 30 | 130 | 52 | 49 | 29 | 40.00% |
| 10 | Eastern spinner dolphin | 29 | 9 | 20 | 11 | 7 | 2 | 55.00% |
| 11 | Whitebelly spinner dolphin | 4 | 1 | 3 | 2 | 1 | 0 | 66.67% |
| 13 | Striped dolphin | 203 | 72 | 131 | 110 | 16 | 5 | 83.97% |
| 17 | Short-beaked common dolphin | 133 | 43 | 90 | 36 | 37 | 17 | 40.00% |
| 200 | Mixed - offshore spotteds and easterns | 71 | 13 | 58 | 24 | 25 | 9 | 41.38% |
| 300 | Mixed - offshore spotteds and whitebellys | 13 | 4 | 9 | 8 | 1 | 0 | 88.89% |
| | | | | | | | | |
| | TOTAL | 613 | 172 | 441 | 243 | 136 | 62 | 55.10% |

Table 6. Percentage of all offshore evasive sightings by stock for SPAM (1998).

| Species Code | Common Name | Total # of Sightings | # of No Records | # of Sightings | # of Evasive Sightings | # of Non-Evasive Sightings | # of Both Ev. and Non-Ev. Sightings | % Purely Evasive Sightings |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| 02 | Offshore spotted dolphin | 159 | 38 | 121 | 60 | 38 | 23 | 49.59% |
| 10 | Eastern spinner dolphin | 21 | 8 | 13 | 8 | 3 | 2 | 61.54% |
| 11 | Whitebelly spinner dolphin | 4 | 1 | 3 | 2 | 1 | 0 | 66.67% |
| 13 | Striped dolphin | 193 | 68 | 125 | 110 | 12 | 3 | 88.00% |
| 17 | Short-beaked common dolphin | 104 | 36 | 68 | 32 | 25 | 11 | 47.06% |
| 200 | Mixed - offshore spotteds and easterns | 58 | 13 | 45 | 22 | 16 | 7 | 48.89% |
| 300 | Mixed - offshore spotteds and whitebellys | 13 | 4 | 9 | 8 | 1 | 0 | 88.89% |
| | | | | | | | | |
| | TOTAL | 552 | 168 | 384 | 242 | 96 | 46 | 63.02% |

Table 7. Summary of the percentage of evasive sightings for all years, MOPS (1986-1990), SPAM (1998), and SPAM without the coastal legs.

| Species Code | Common Name | % Evasive Sightings | | | |
|---|---|---|---|---|---|
| | | All Years | MOPS | SPAM | SPAM w/o Coastal Legs |
| 02 | Offshore spotted dolphin | 64.20% | 75.64% | 40.00% | 49.59% |
| 10 | Eastern spinner dolphin | 63.75% | 66.67% | 55.00% | 61.54% |
| 11 | Whitebelly spinner dolphin | 85.11% | 86.36% | 66.67% | 66.67% |
| 13 | Striped dolphin | 85.23% | 85.50% | 83.97% | 88.00% |
| 17 | Short-beaked common dolphin | 57.20% | 67.32% | 40.00% | 47.06% |
| 200 | Mixed - offshore spotteds and easterns | 52.09% | 56.05% | 41.38% | 48.89% |
| 300 | Mixed - offshore spotteds and whitebellys | 93.46% | 93.88% | 88.89% | 88.89% |

## Figure Legend

Figure 1. Types and percentages of evasive behavior by offshore spotted dolphins.

Figure 2. Types and percentages of evasive behavior by eastern spinner dolphins.

Figure 3. Types and percentages of evasive behavior by whitebelly spinner dolphins.

Figure 4. Types and percentages of evasive behavior by short-beaked common dolphins.

Figure 5. Types and percentages of evasive behavior by striped dolphins.

Figure 6. All sightings (1986-1990 & 1998) plotted geographically by behavior.

Figure 7. Offshore spotted dolphin sightings (1986-1990 & 1998) plotted geographically by behavior.

Figure 8. Eastern spinner dolphin sightings (1986-1990 & 1998) plotted geographically by behavior.

Figure 9. Whitebelly spinner dolphin sightings (1986-1990 & 1998) plotted geographically by behavior.

Figure 10. Common dolphin sightings (1986-1990 & 1998) plotted geographically by behavior.

Figure 11. Striped dolphin sightings (1986-1990 & 1998) plotted geographically by behavior.

Figure 12. Offshore spotted and eastern spinner dolphin mixed school sightings (1986-1990 & 1998) plotted geographically by behavior.

Figure 13. Offshore spotted and whitebelly spinner dolphin mixed school sightings (1986-1990 & 1998) plotted geographically by behavior.

Figure 14. All sightings of dolphin schools for MOPS (1986-1990) plotted geographically by behavior.

Figure 15. Offshore spotted dolphin sightings for MOPS (1986-1990) plotted geographically by behavior.

Figure 16. Eastern spinner dolphin sightings for MOPS (1986-1990) plotted geographically by behavior.

Figure 17. Whitebelly spinner dolphin sightings for MOPS (1986-1990) plotted geographically by behavior.

Figure 18. Common dolphin sightings for MOPS (1986-1990) plotted geographically by behavior.

Figure 19. Striped dolphin sightings for MOPS (1986-1990) plotted geographically by behavior.

Figure 20. Offshore spotted and eastern spinner dolphin mixed school sightings for MOPS (1986-1990) plotted geographically by behavior.

Figure 21. Offshore spotted and whitebelly spinner dolphin mixed school sightings for MOPS (1986-1990) plotted geographically by behavior.

Figure 22. All sightings of dolphin schools for SPAM (1998) plotted geographically by behavior.

Figure 23. Offshore spotted dolphin sightings for SPAM (1998) plotted geographically by behavior.

Figure 24. Eastern spinner dolphin sightings for SPAM (1998) plotted geographically by behavior.

Figure 25. Common dolphin sightings for SPAM (1998) plotted geographically by behavior.

Figure 26. Striped dolphin sightings for SPAM (1998) plotted geographically by behavior.

Figure 27. Offshore spotted and eastern spinner dolphin mixed school sightings for SPAM (1998) plotted geographically by behavior.

Figure 28. Offshore spotted and whitebelly spinner dolphin mixed school sightings for SPAM (1998) plotted geographically by behavior.

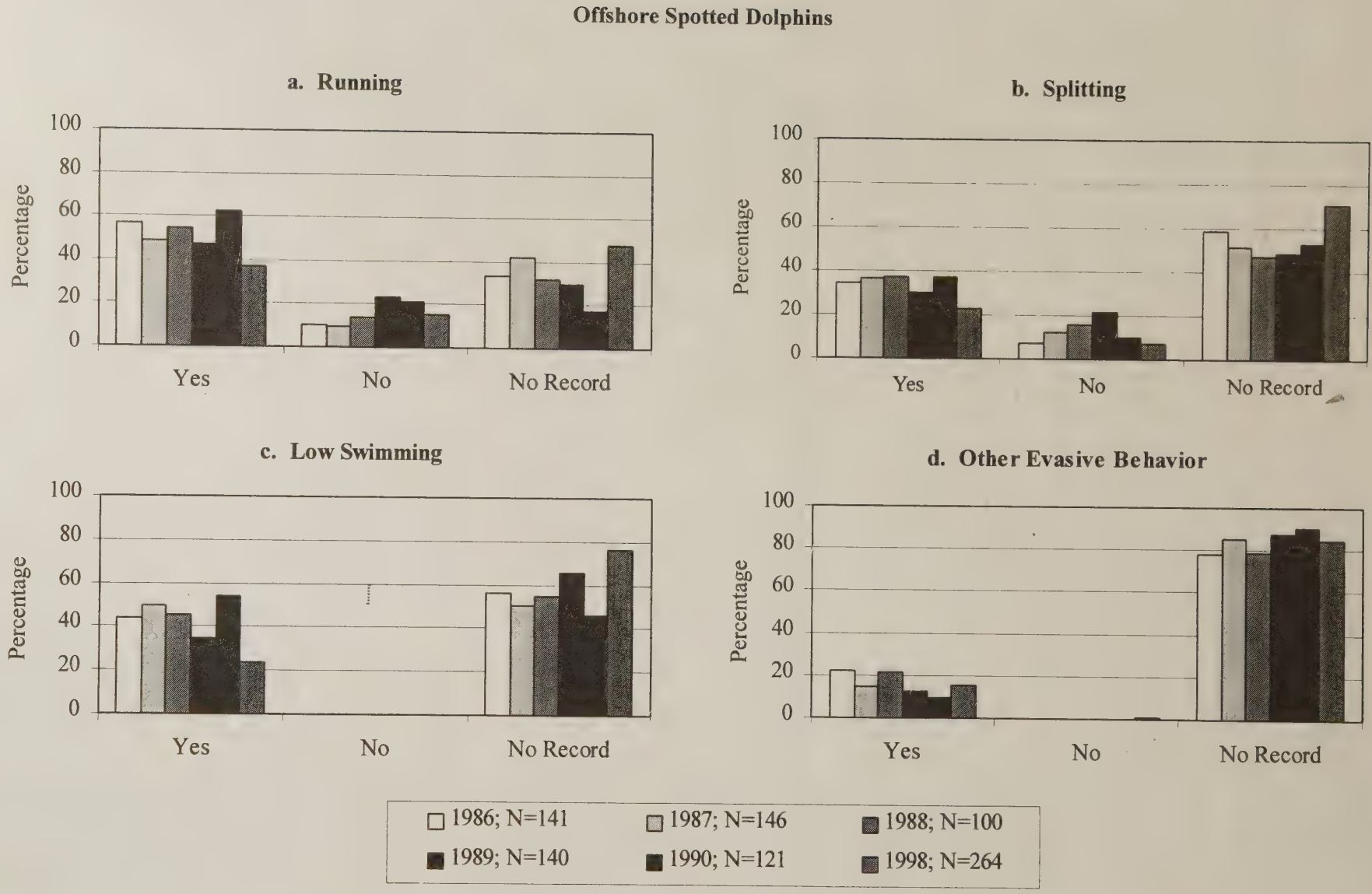


Figure 1. Percentages of evasive behavior by offshore spotted dolphins, 1986–1990 and 1998. N = the number of school sightings.

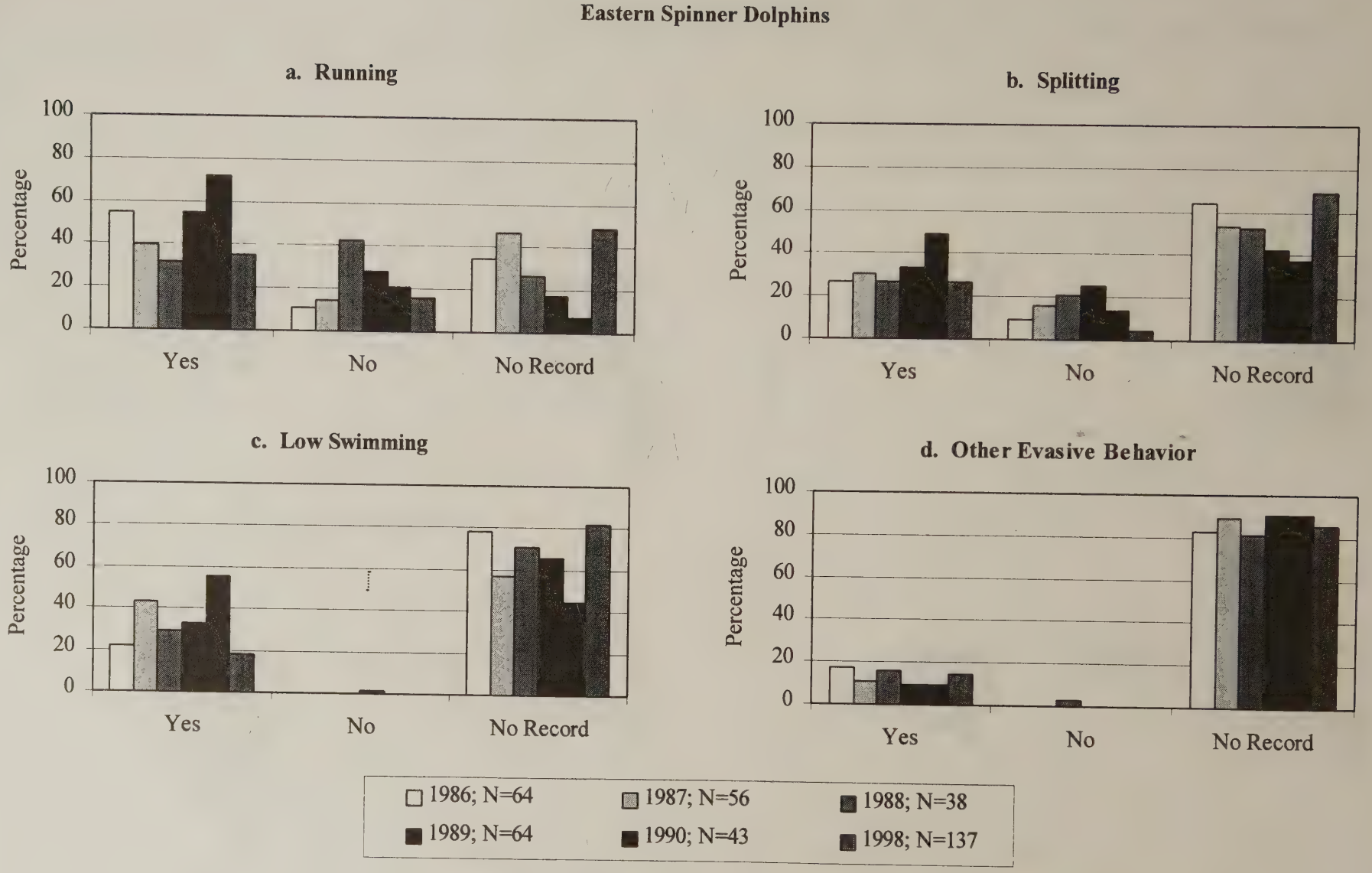


Figure 2. Percentages of evasive behavior by eastern spinner dolphins, 1986-1990 and 1998. N = the number of school sightings.

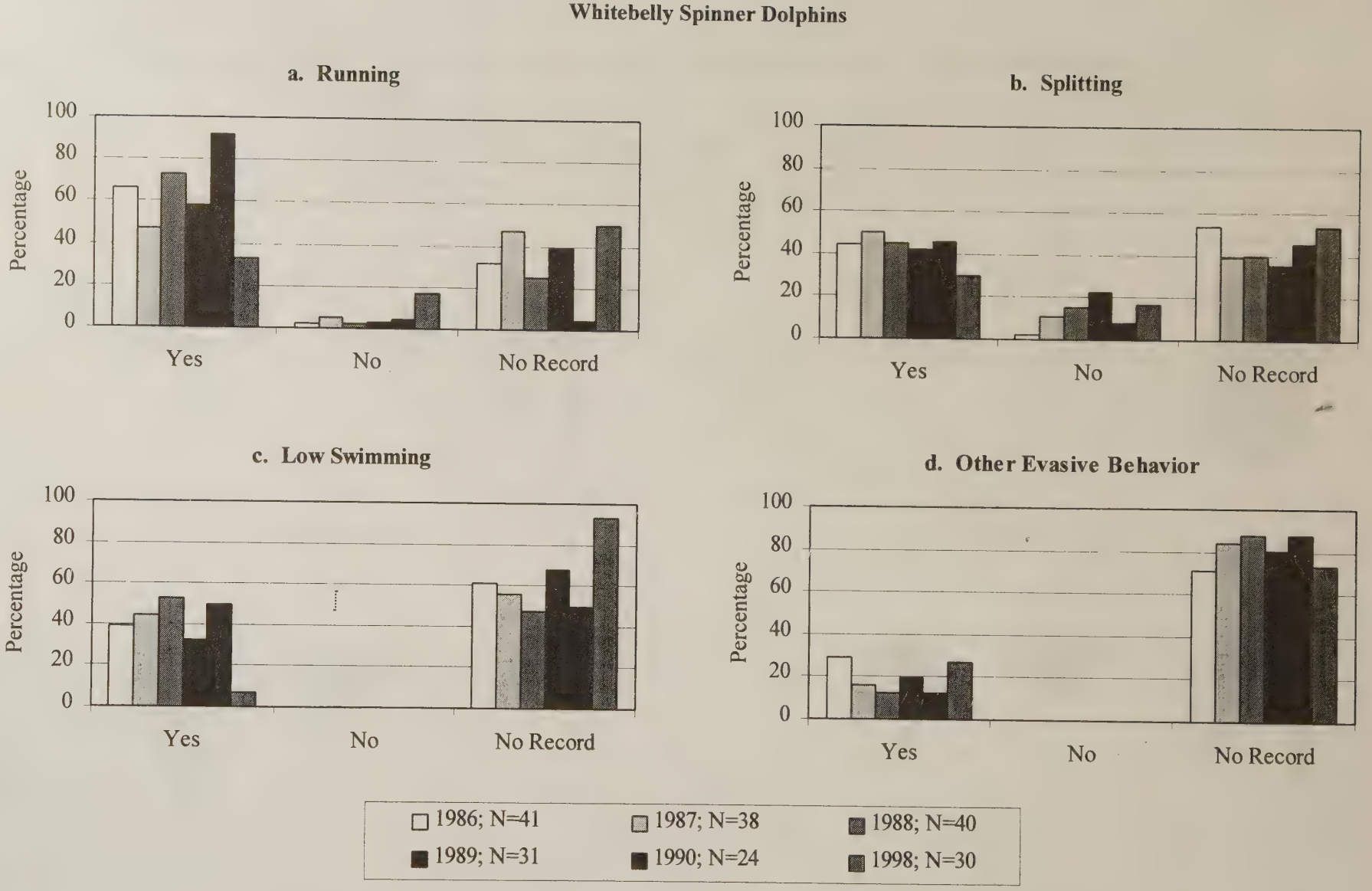


Figure 3. Percentages of evasive behavior by whitebelly spinner dolphins, 1986-1990 and 1998. N = the number of school sightings.

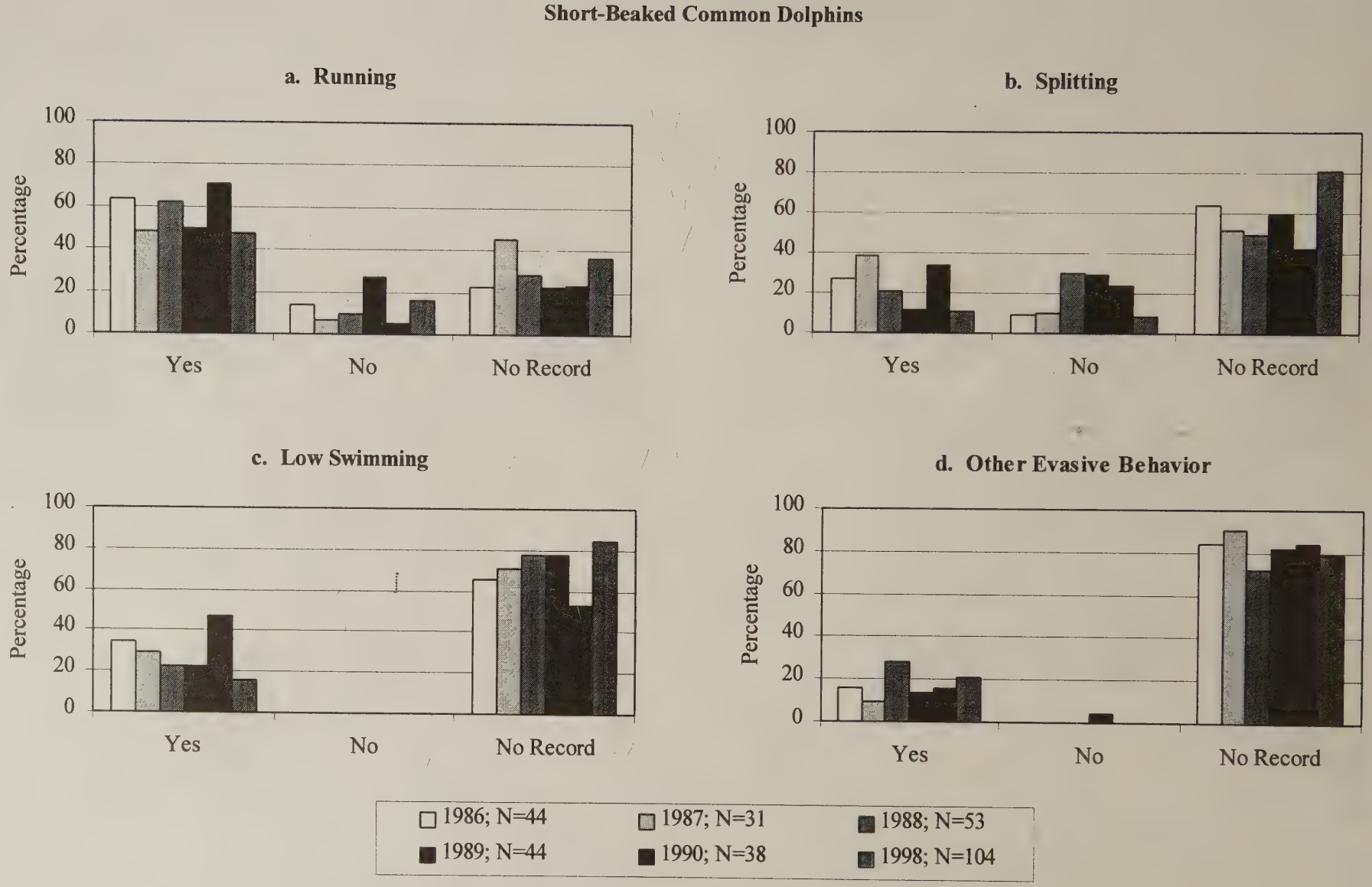


Figure 4. Percentages of evasive behavior by short-beaked common dolphins, 1986-1990 and 1998. N = the number of school sightings.

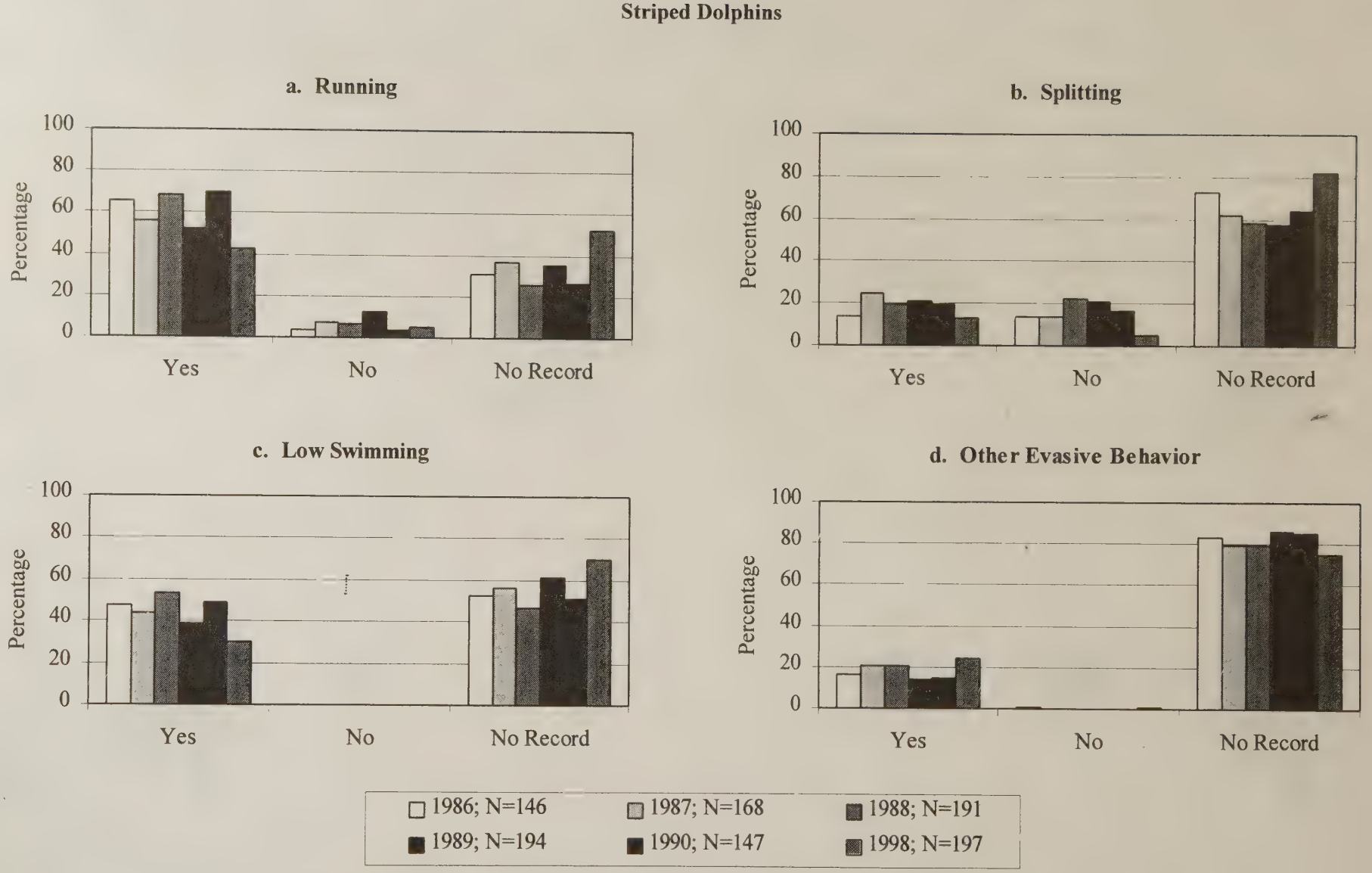


Figure 5. Percentages of evasive behavior by striped dolphins, 1986-1990 and 1998. N = the number of school sightings.

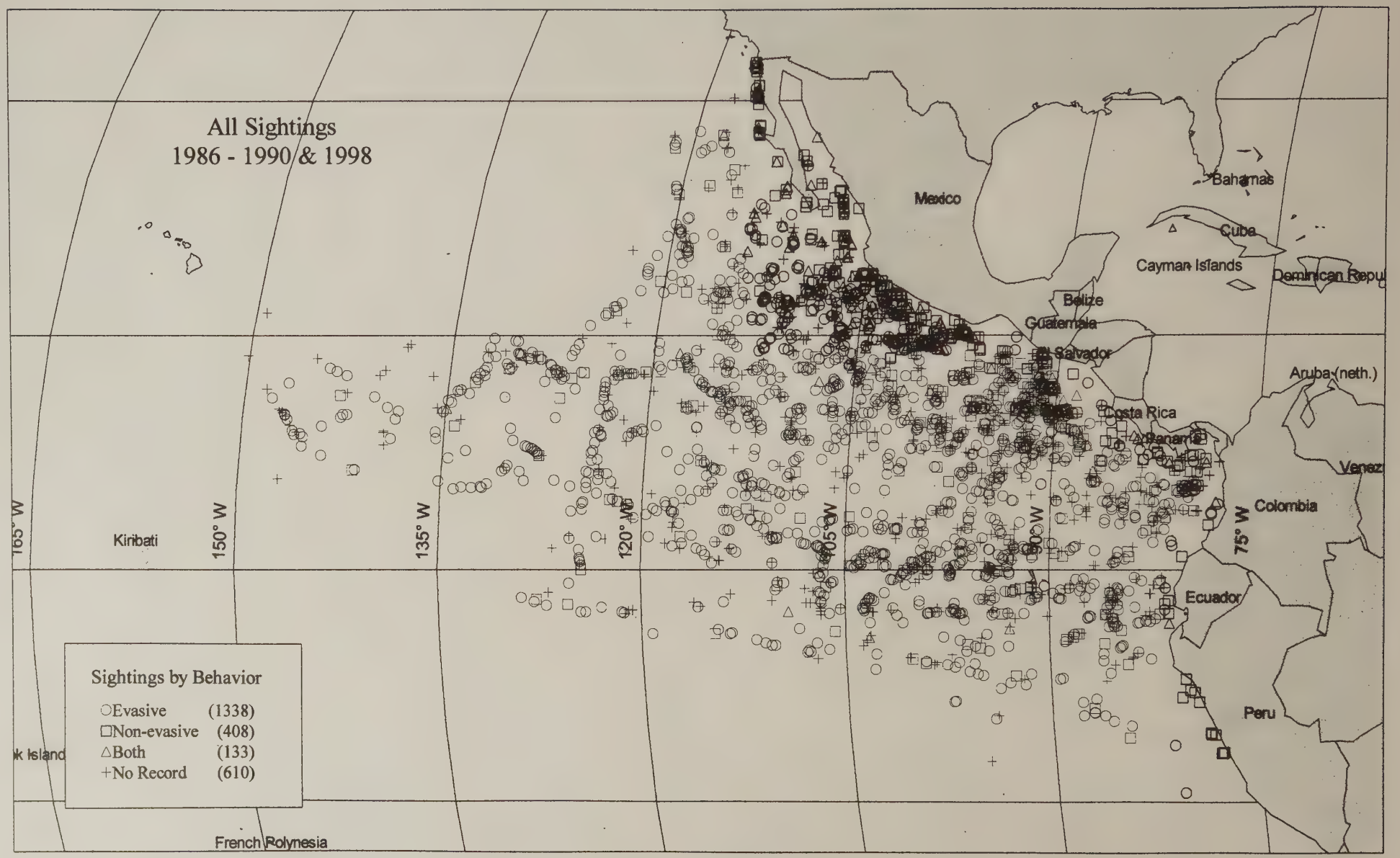


Figure 6. All sightings (1986-1990 & 1998) plotted geographically by behavior.

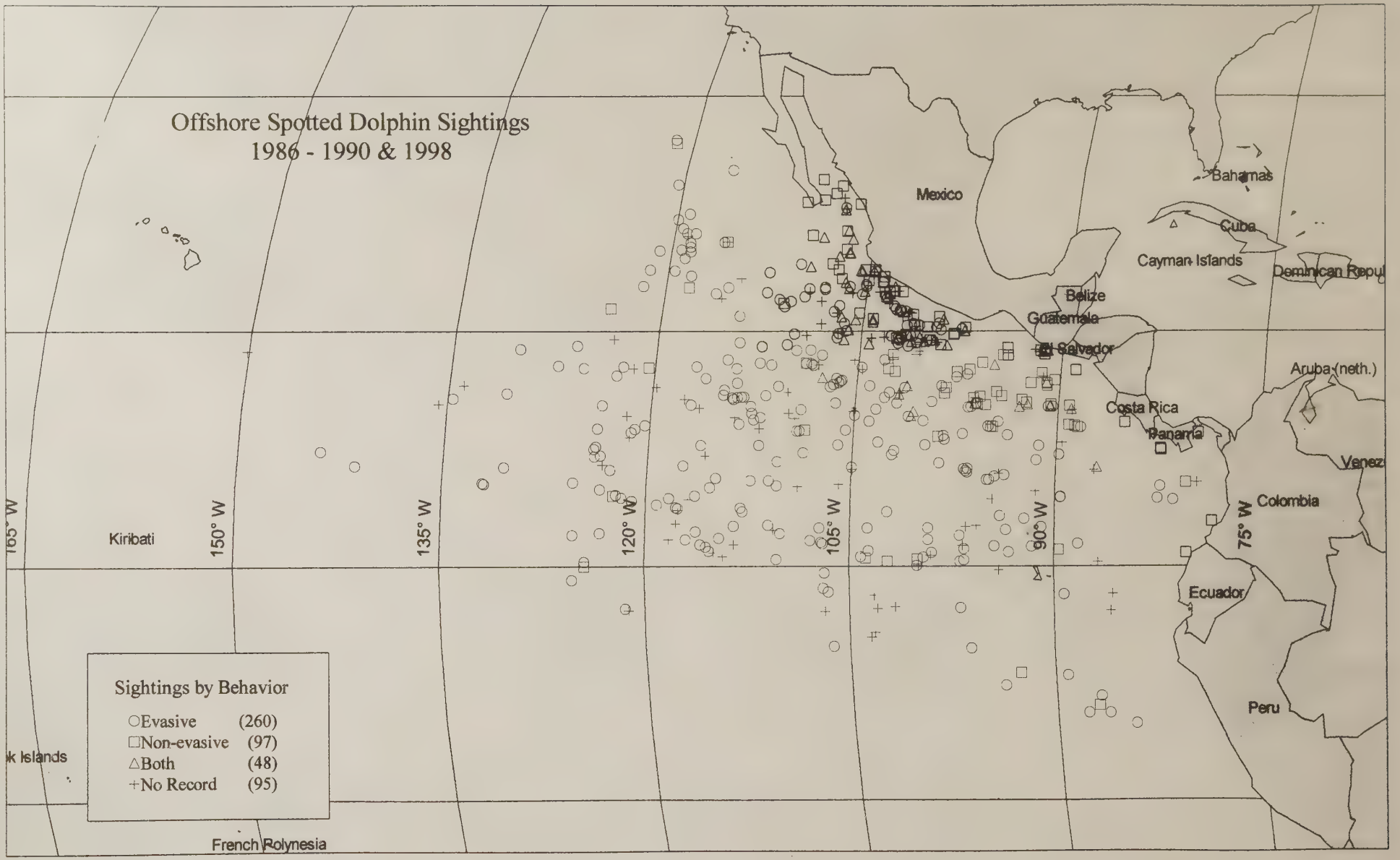


Figure 7. Offshore spotted dolphin sightings (1986-1990 &1998) plotted geographically by behavior.

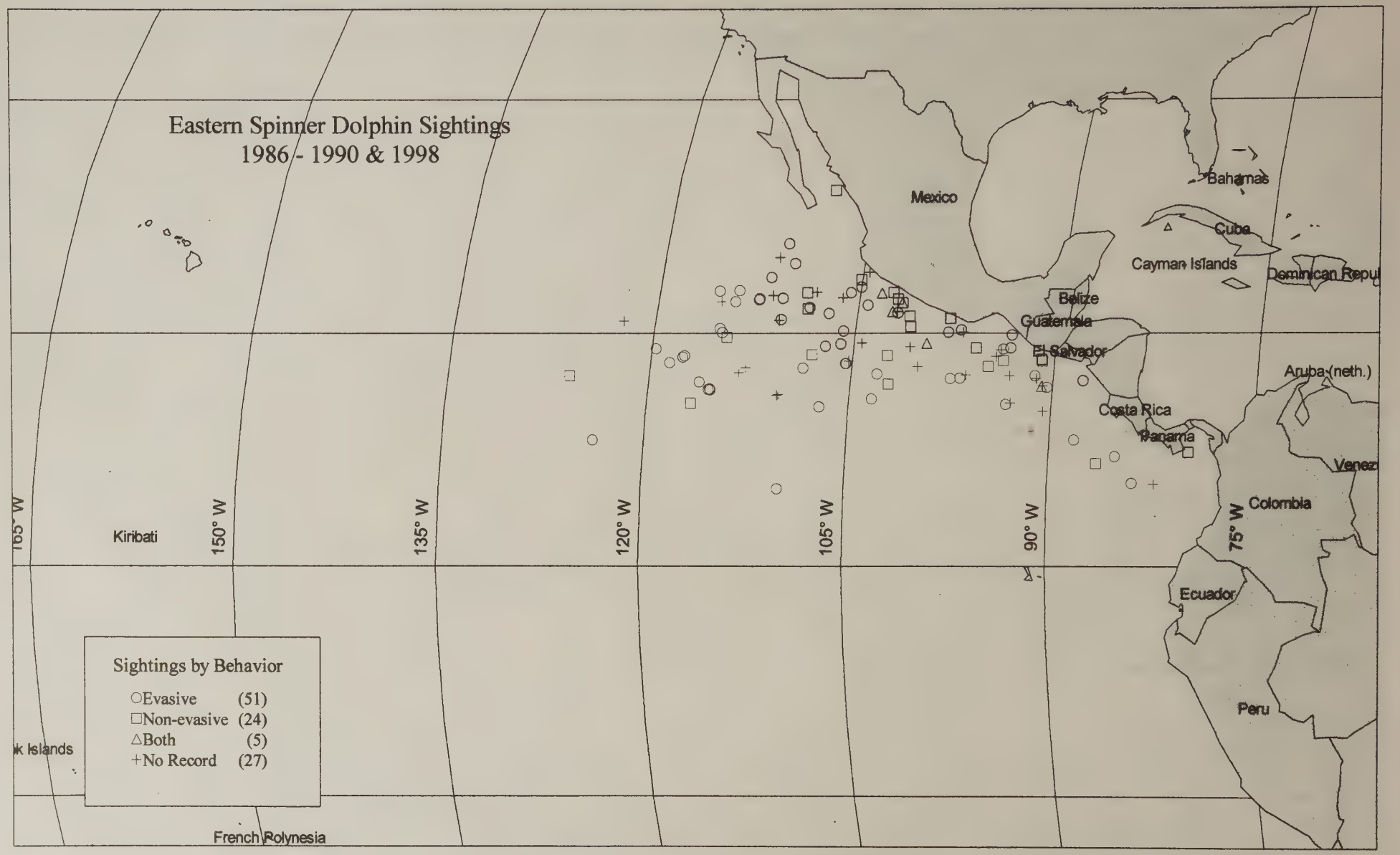


Figure 8. Eastern spinner dolphin sightings (1986-1990 & 1998) plotted geographically by behavior.

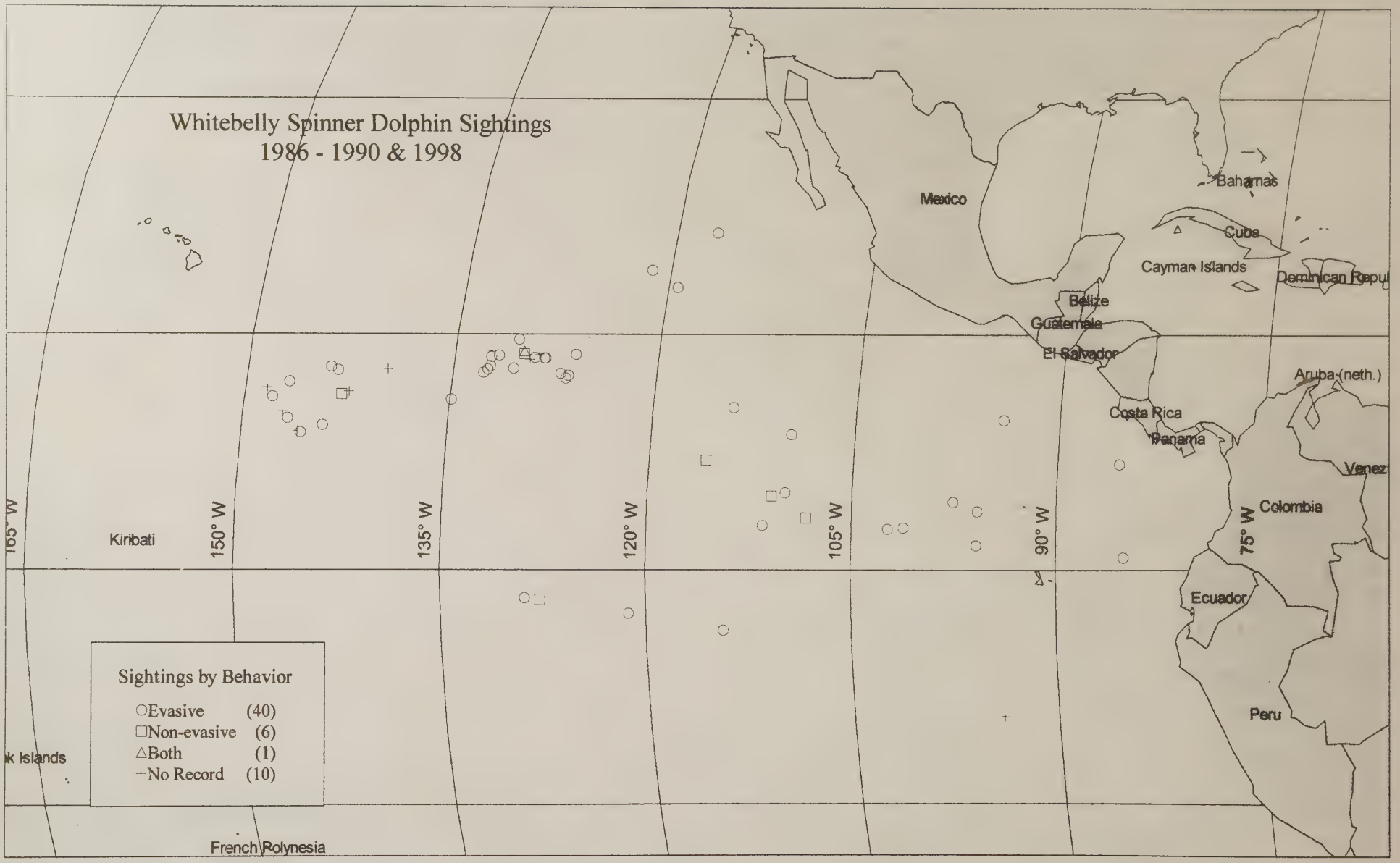


Figure 9. Whitebelly spinner dolphin sightings (1986-1990 & 1998) plotted geographically by behavior.

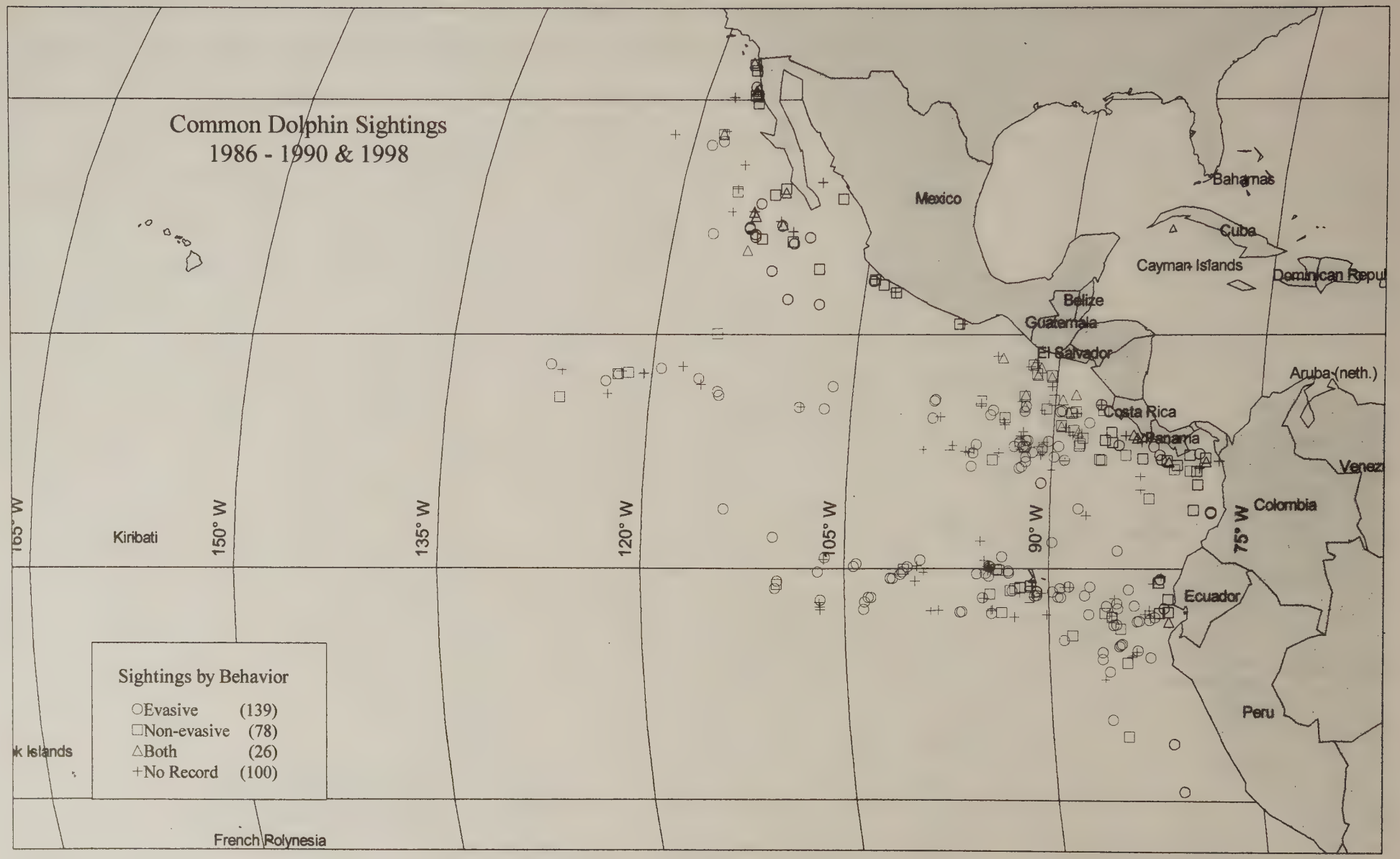


Figure 10. Common dolphin sightings (1986-1990 & 1998) plotted geographically by behavior.

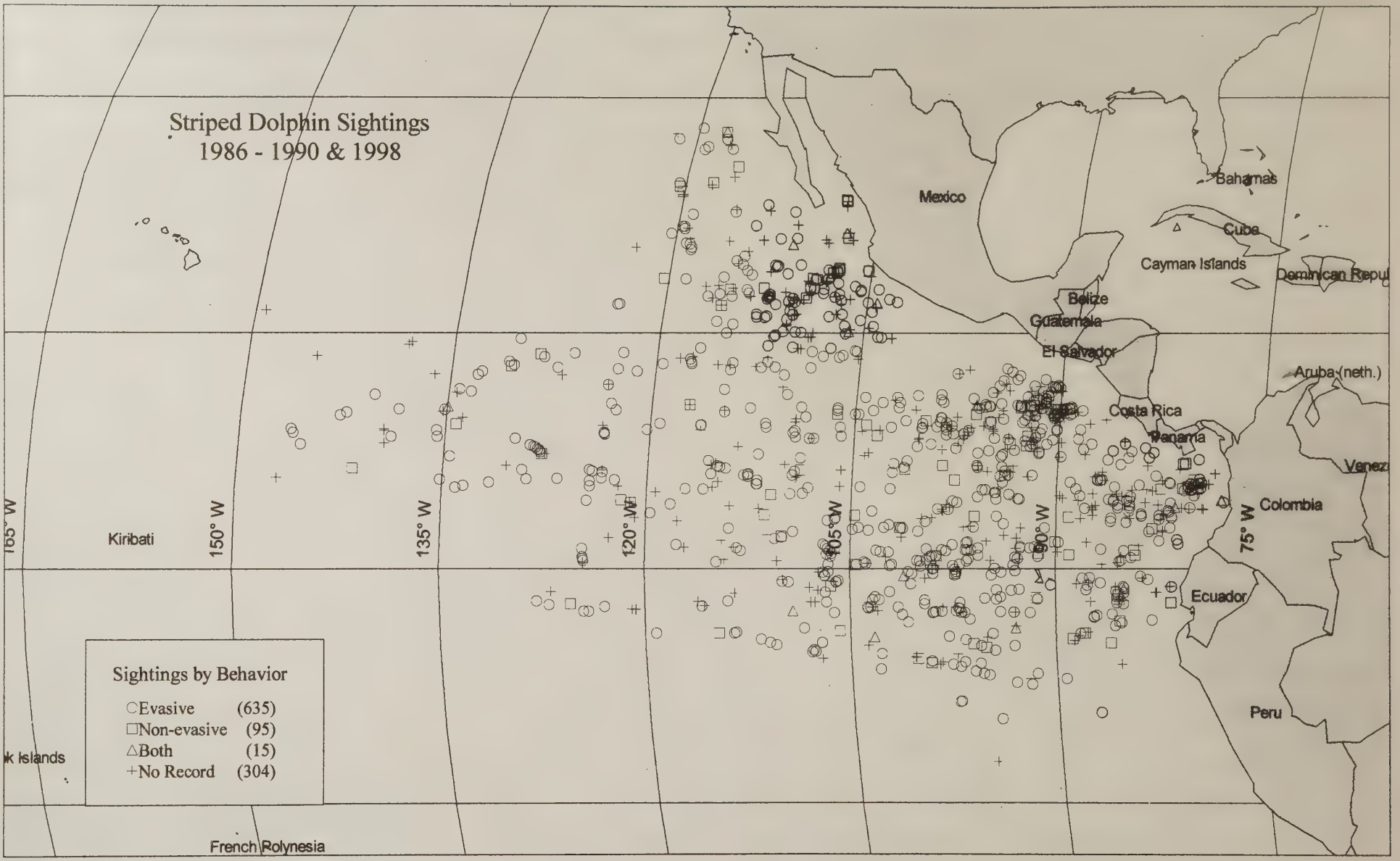


Figure 11. Striped dolphin sightings (1986-1990 & 1998) plotted geographically by behavior.

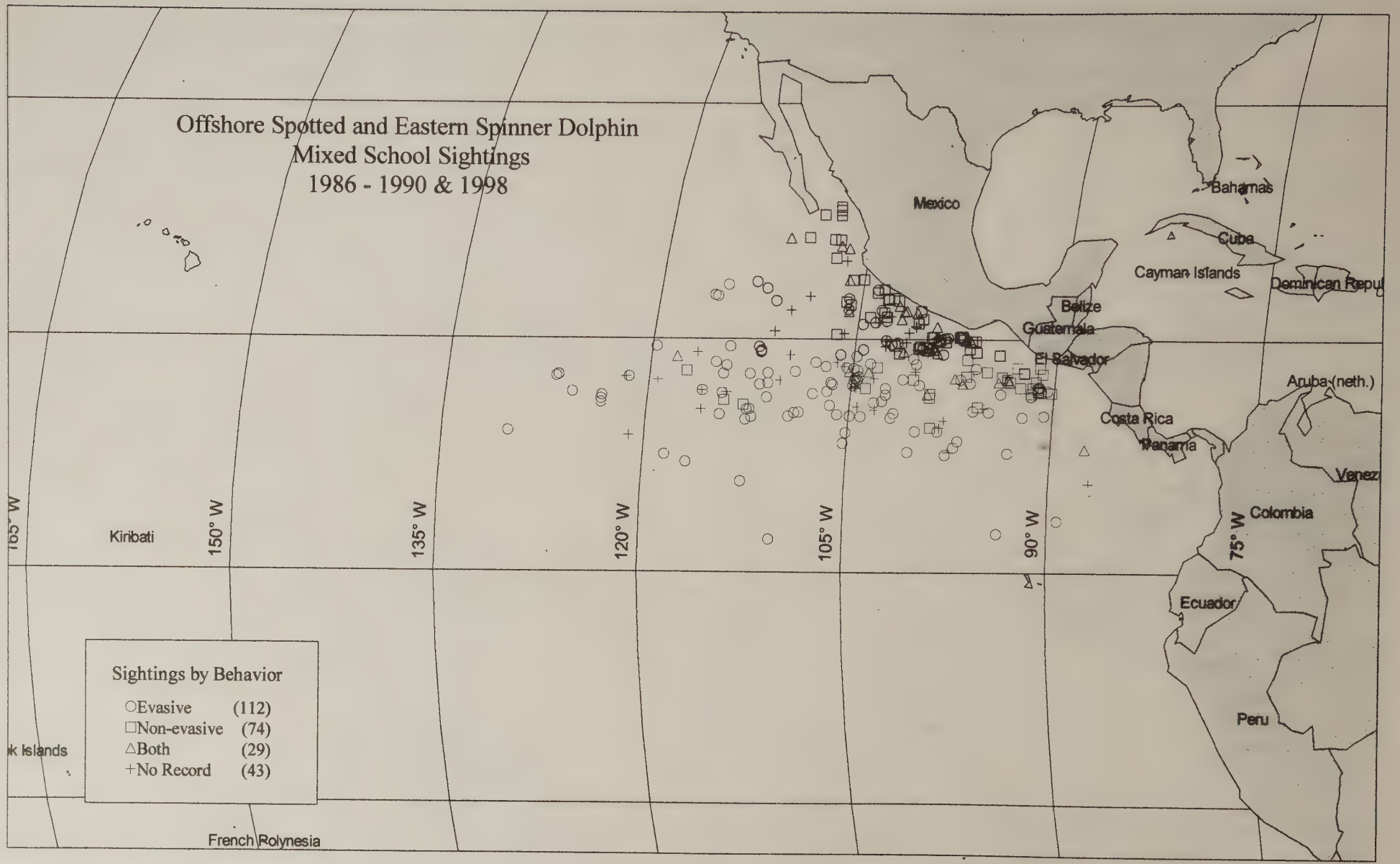


Figure 12. Offshore spotted and eastern spinner dolphin mixed school sightings (1986-1990 & 1998) plotted geographically by behavior.

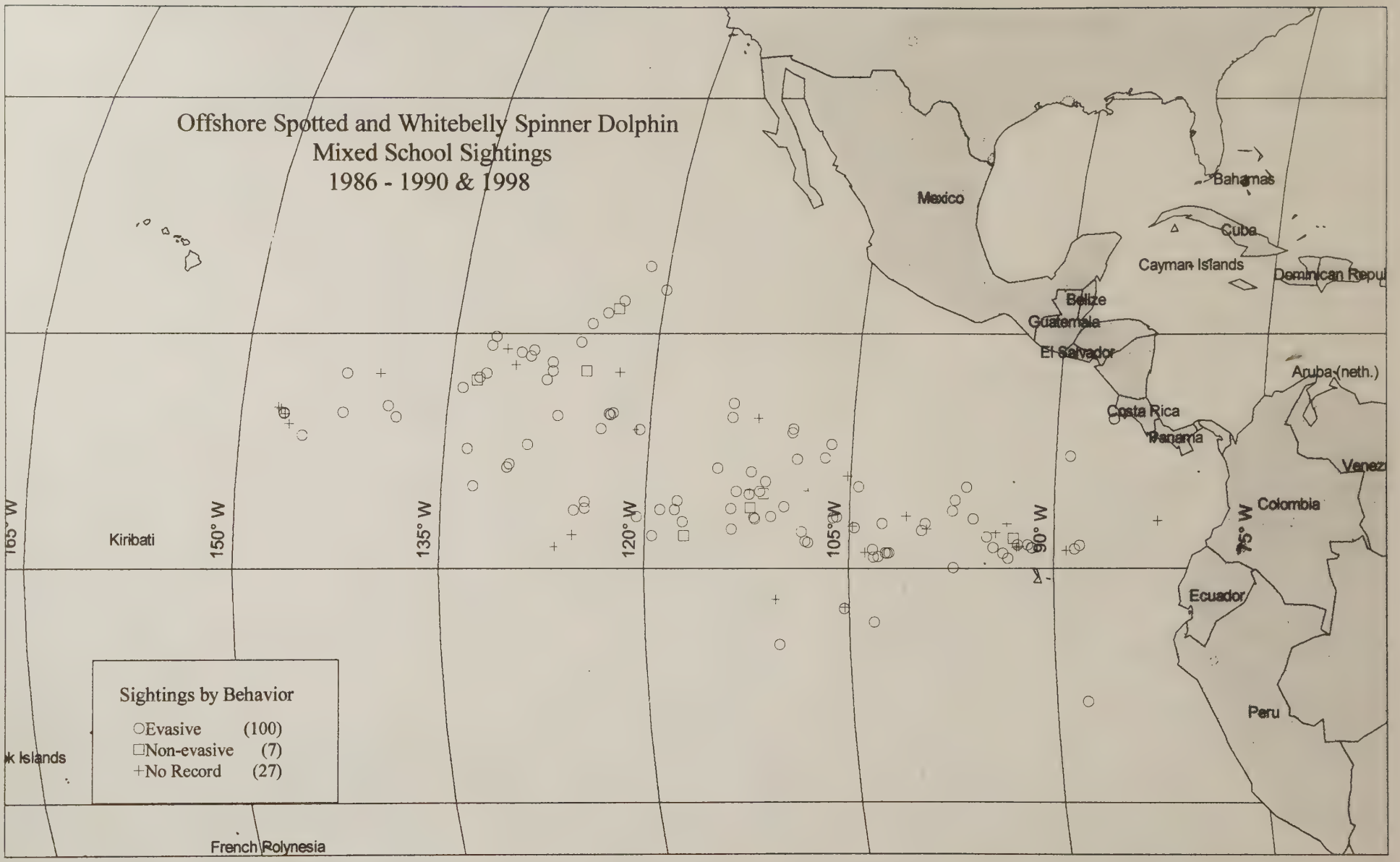


Figure 13. Offshore spotted and whitebelly spinner dolphin mixed school sightings (1986-1990 & 1998) plotted geographically by behavior.

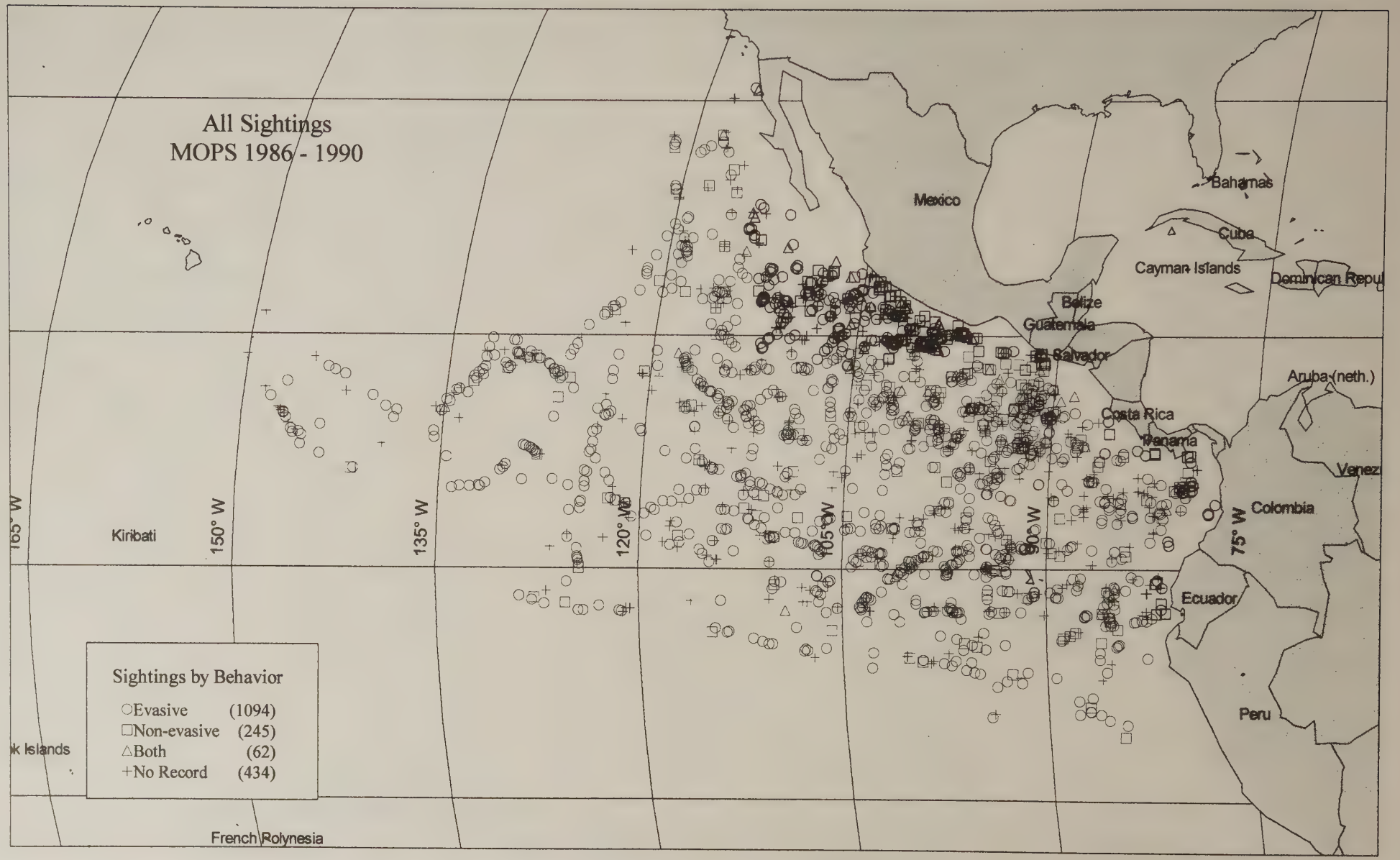


Figure 14. All sightings of dolphin schools for MOPS (1986-1990) plotted geographically by behavior.

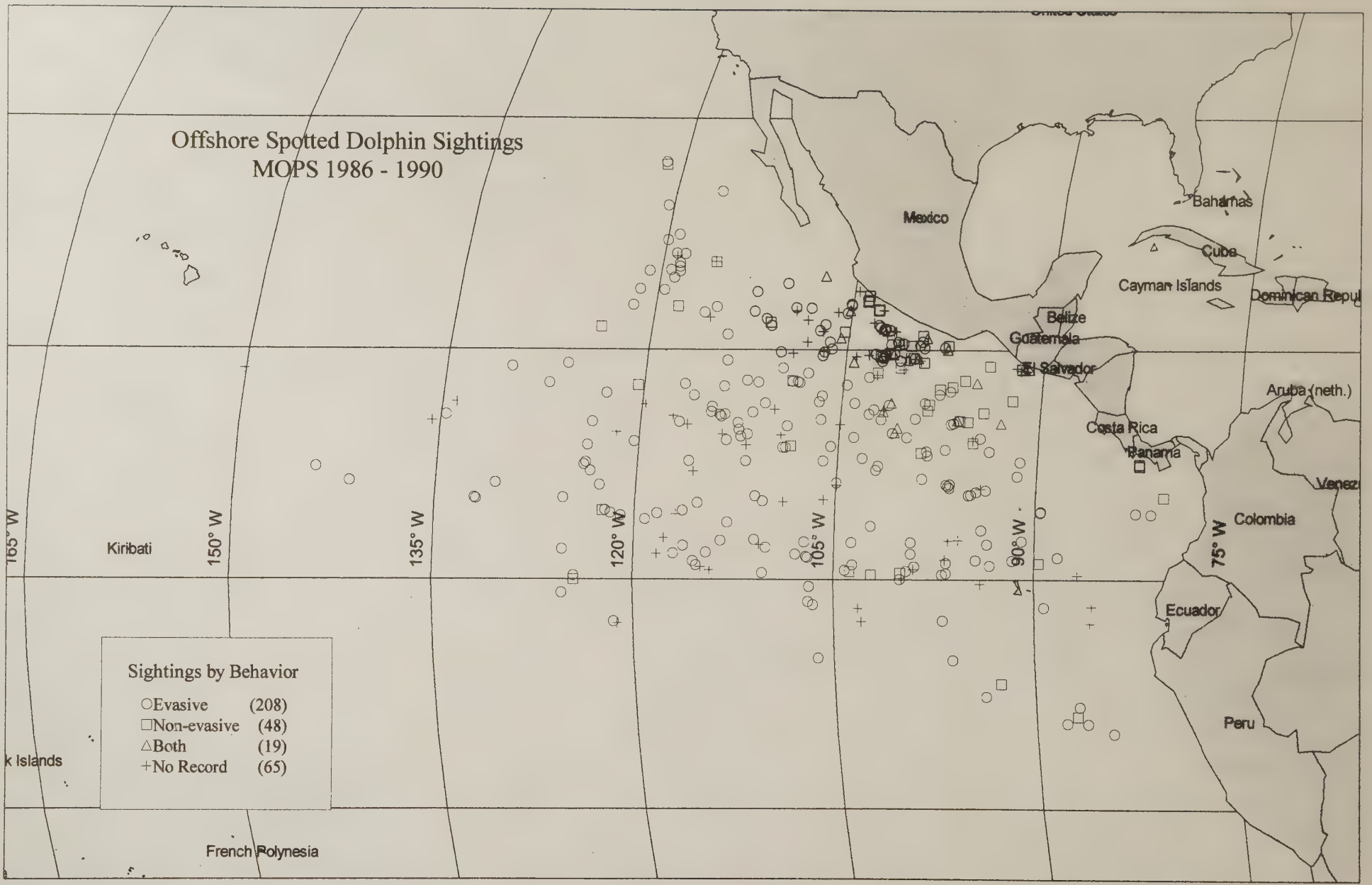


Figure 15. Offshore spotted dolphin sightings for MOPS (1986-1990) plotted geographically by behavior.

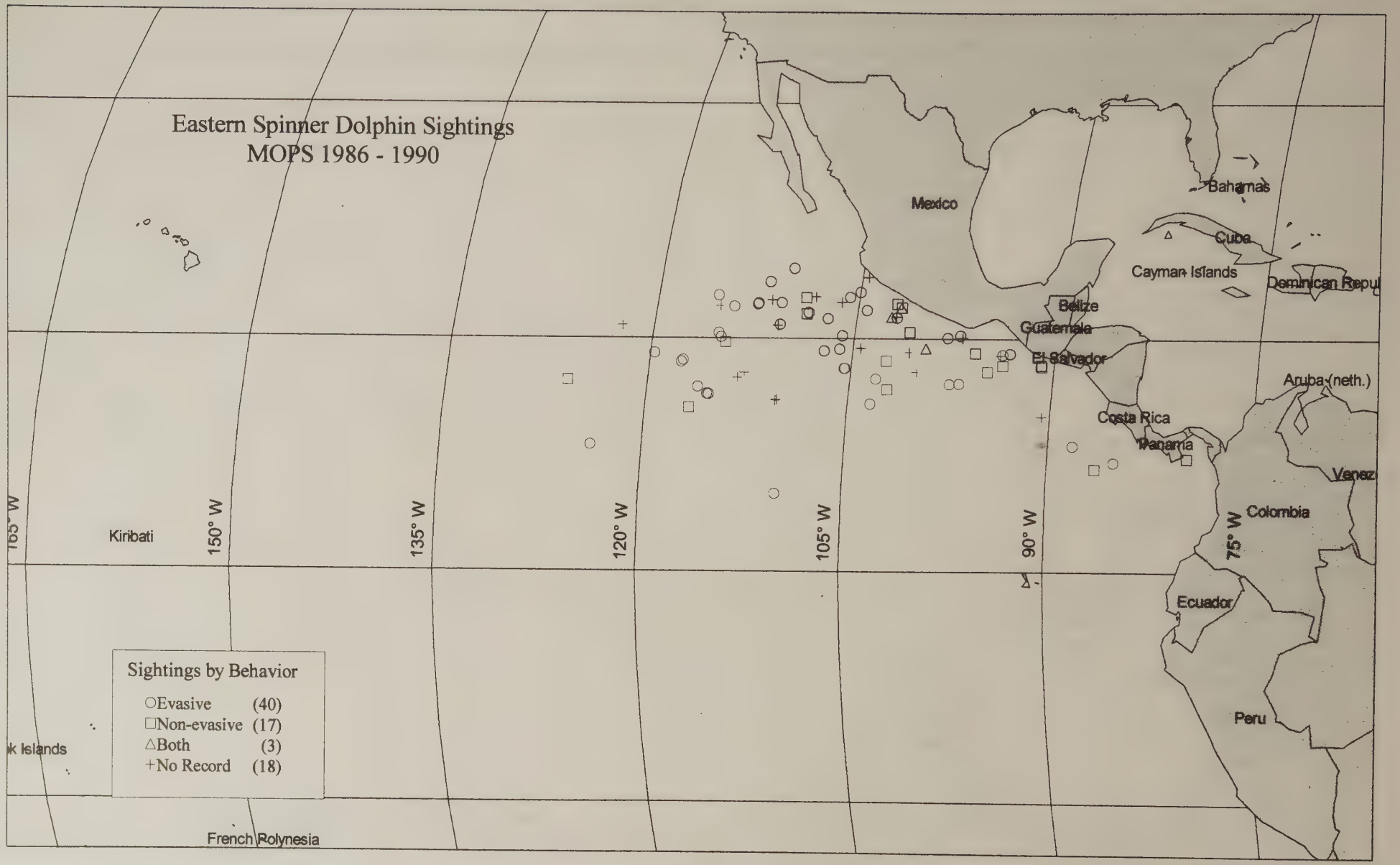


Figure 16. Eastern spinner dolphin sightings for MOPS (1986-1990) plotted geographically by behavior.

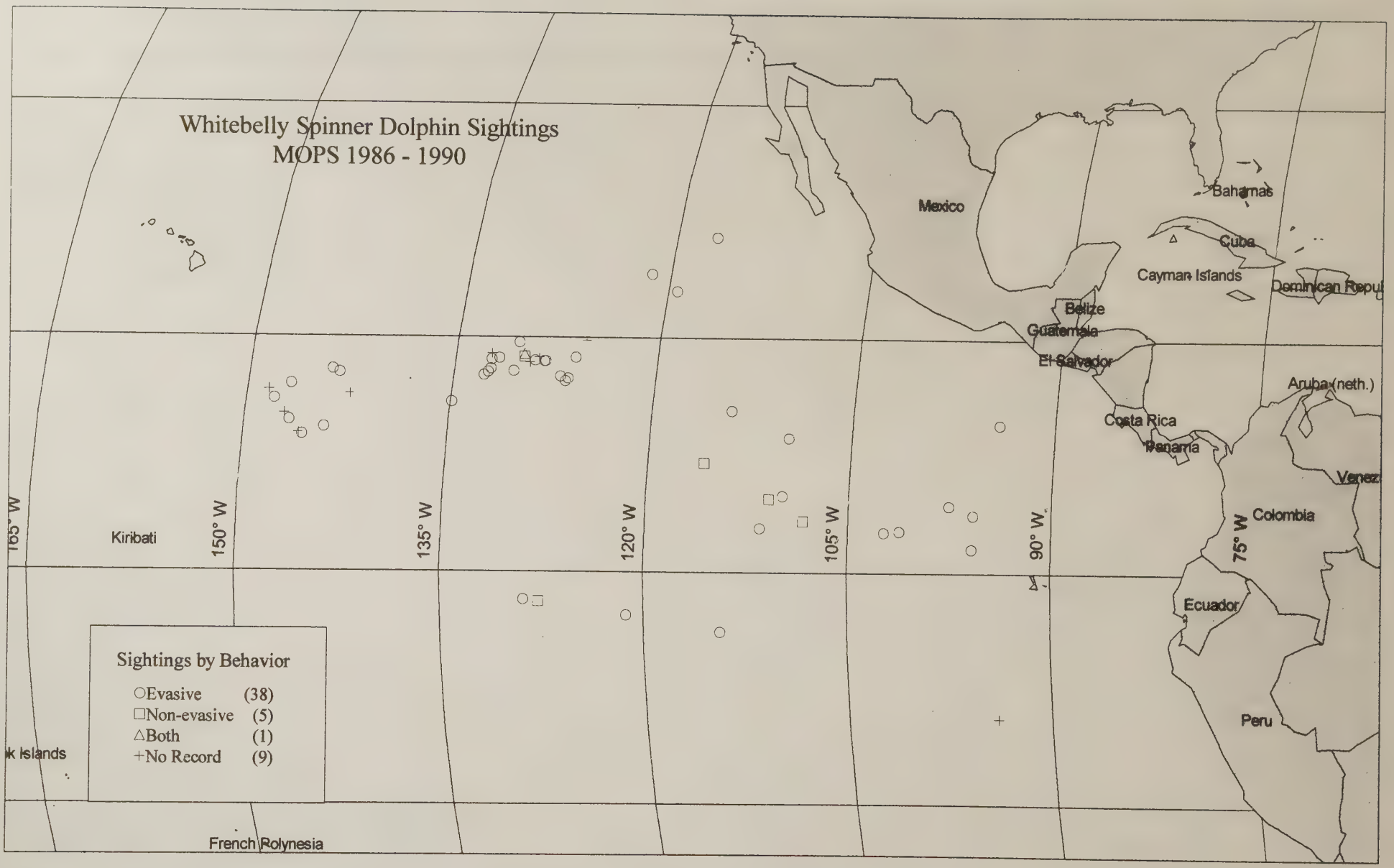


Figure 17. Whitebelly spinner dolphin sightings for MOPS (1986-1990) plotted geographically by behavior.

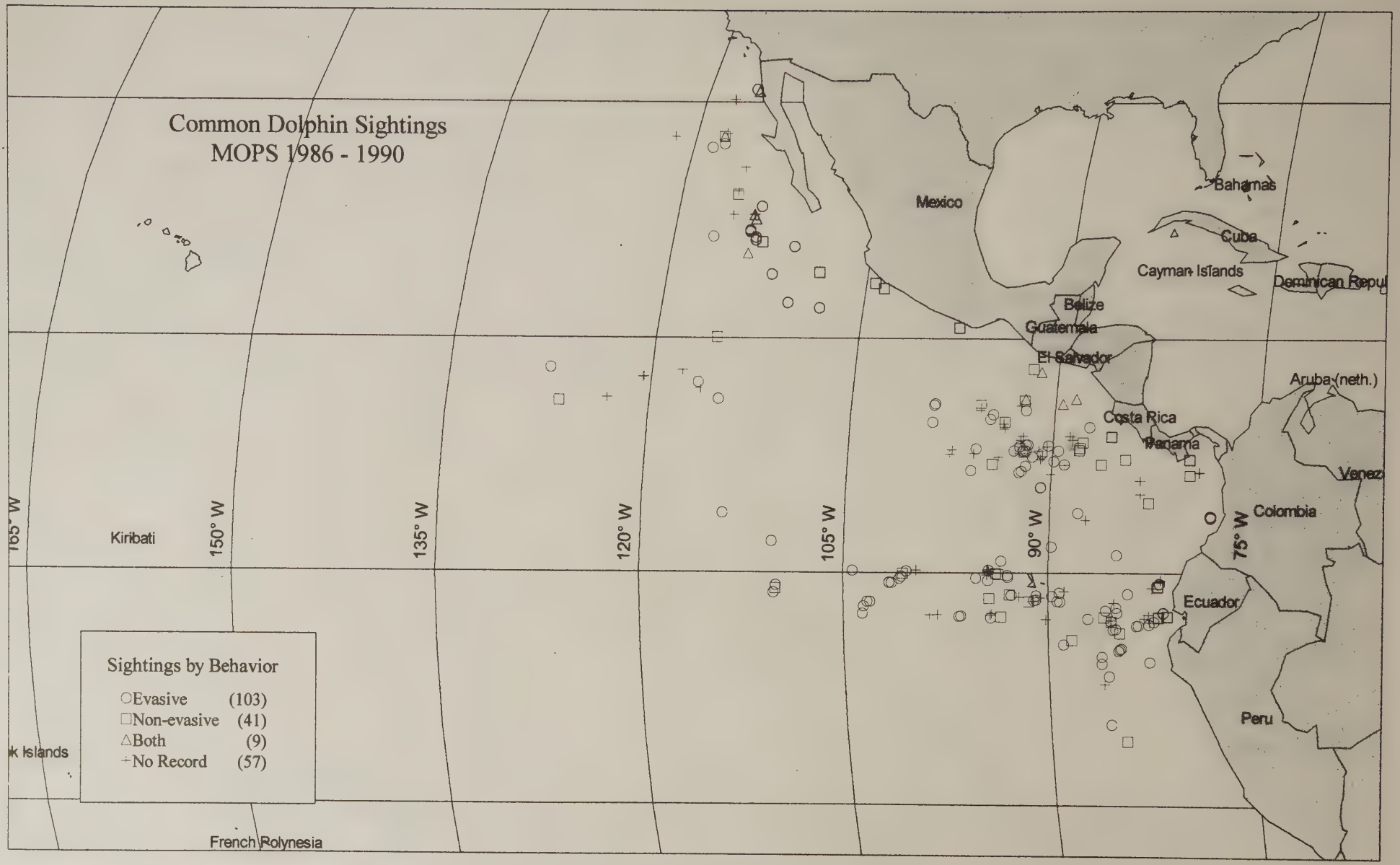


Figure 18. Common dolphin sightings for MOPS (1986-1990) plotted geographically by behavior.

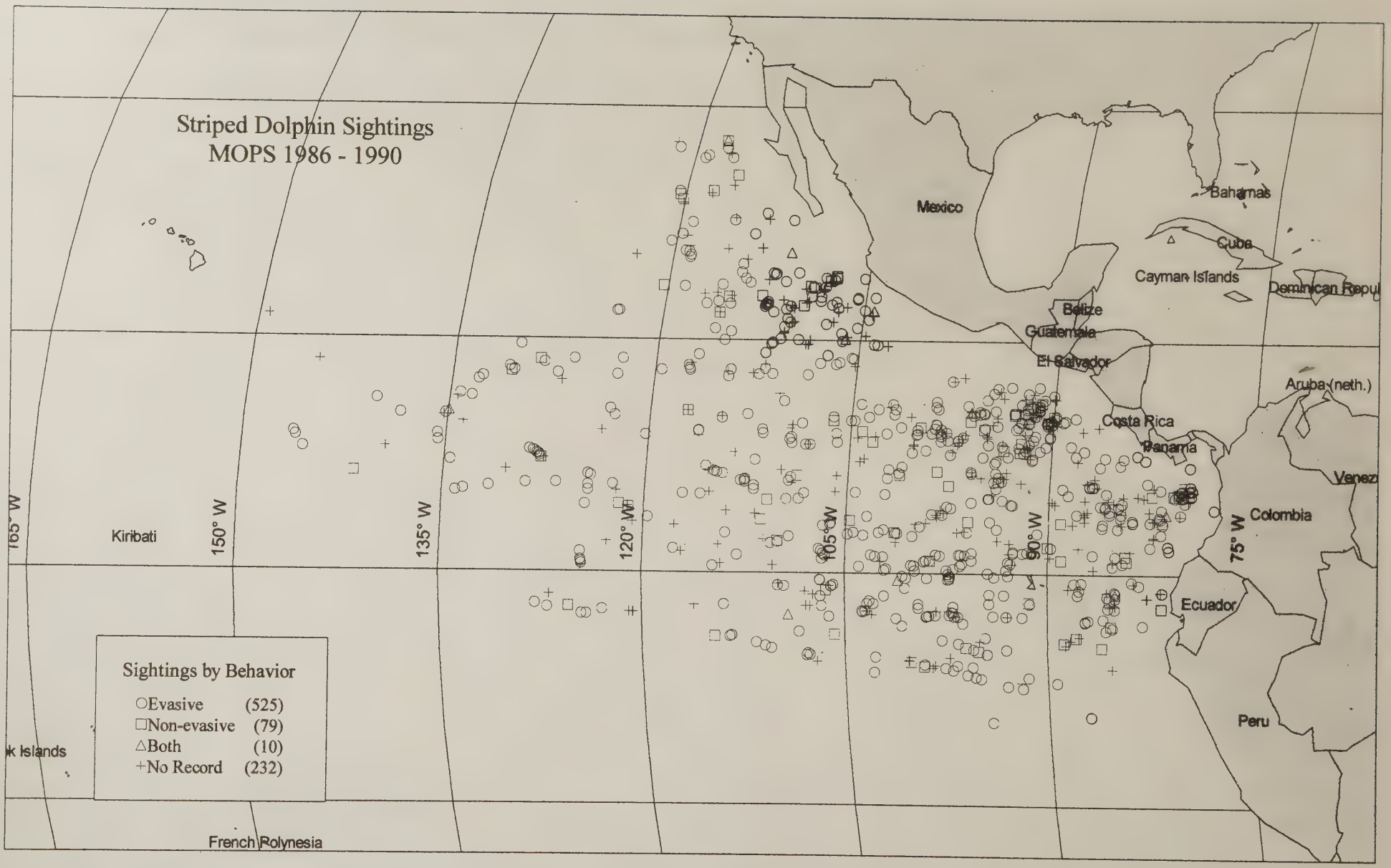


Figure 19. Striped dolphin sightings for MOPS (1986-1990) plotted geographically by behavior.

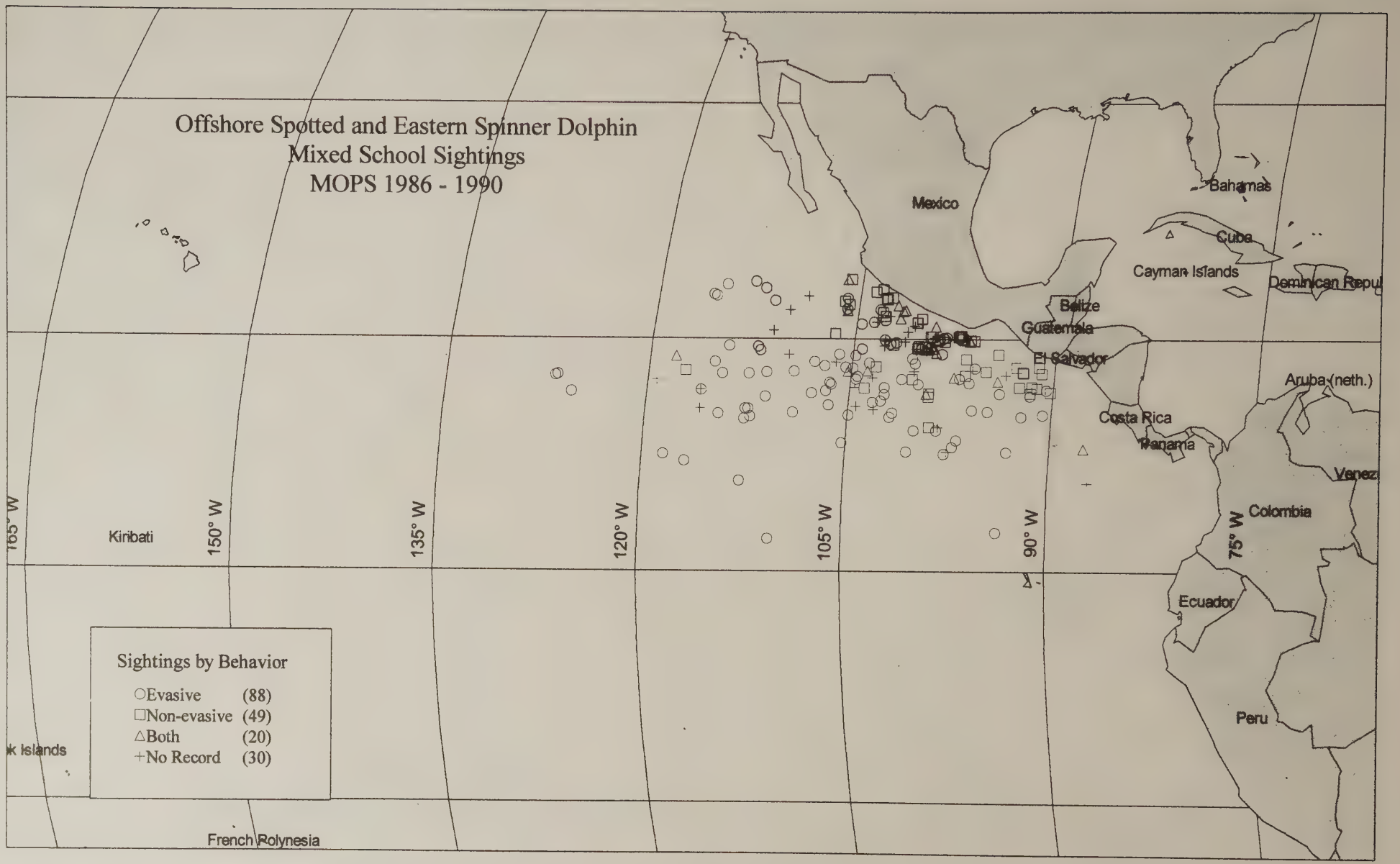


Figure 20. Offshore spotted and eastern spinner dolphin mixed school sightings for MOPS (1986-1990) plotted geographically by behavior.

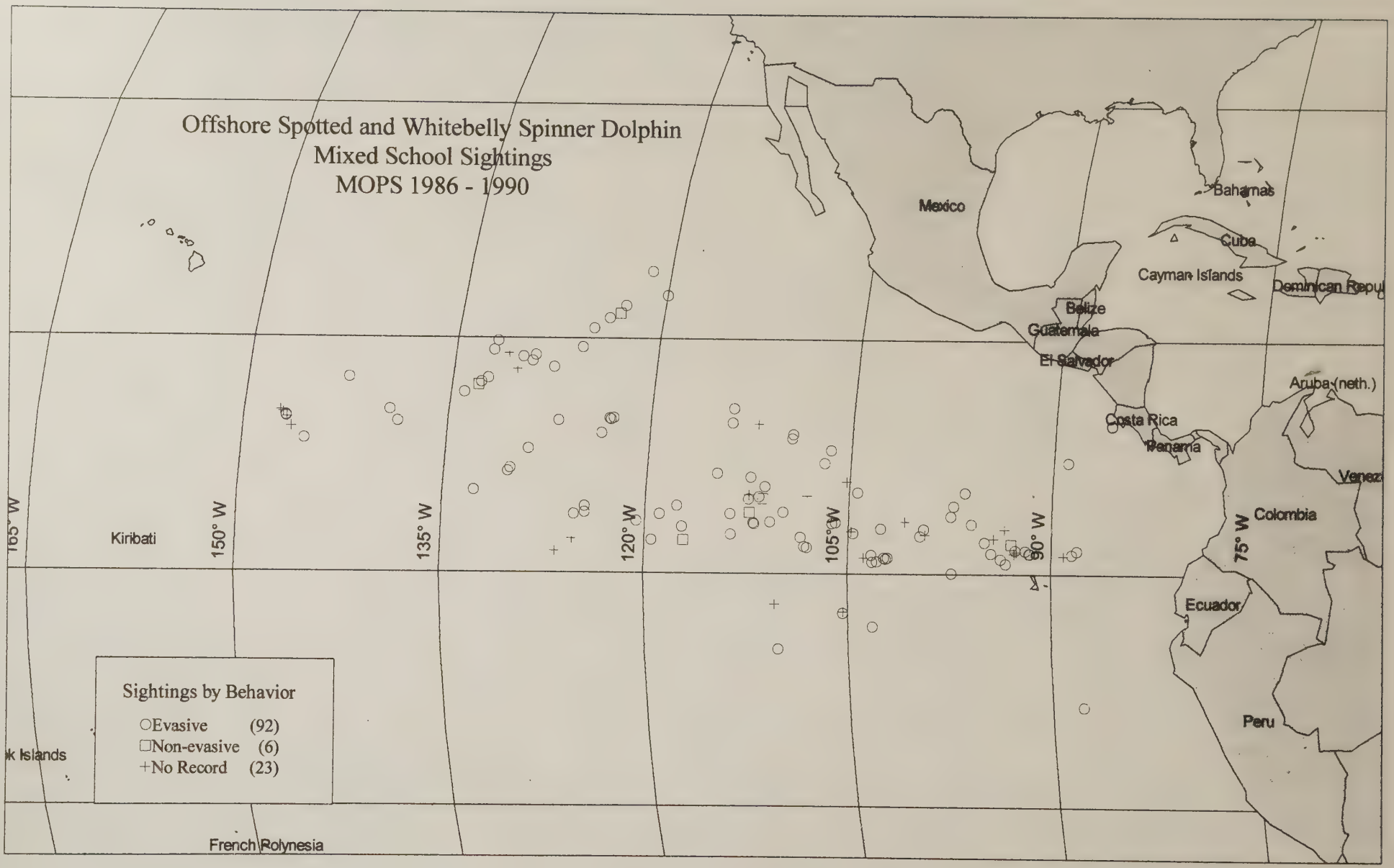


Figure 21. Offshore spotted and whitebelly spinner dolphin mixed school sightings for MOPS (1986-1990) plotted geographically by behavior.

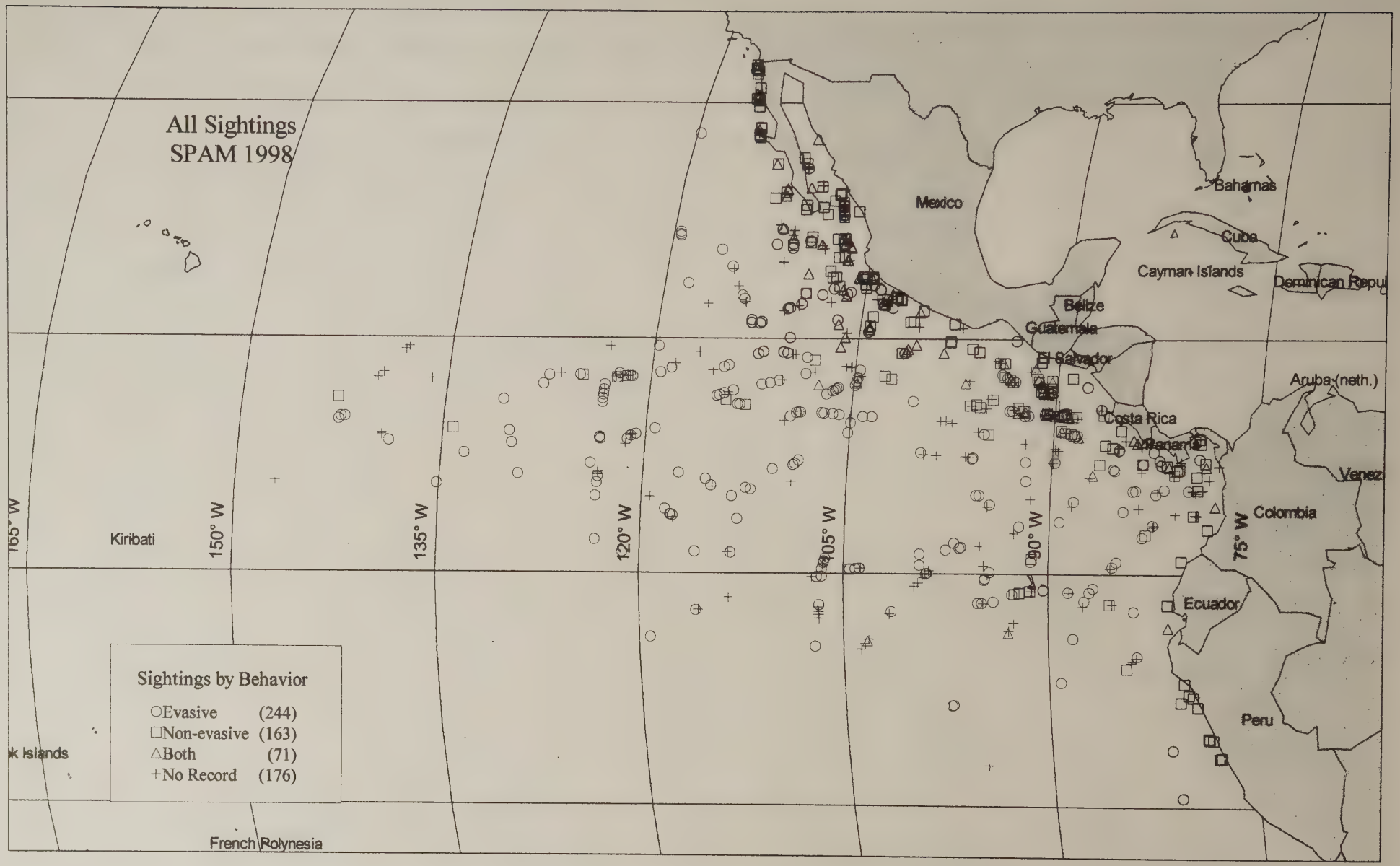


Figure 22. All sightings of dolphin schools for SPAM (1998) plotted geographically by behavior.

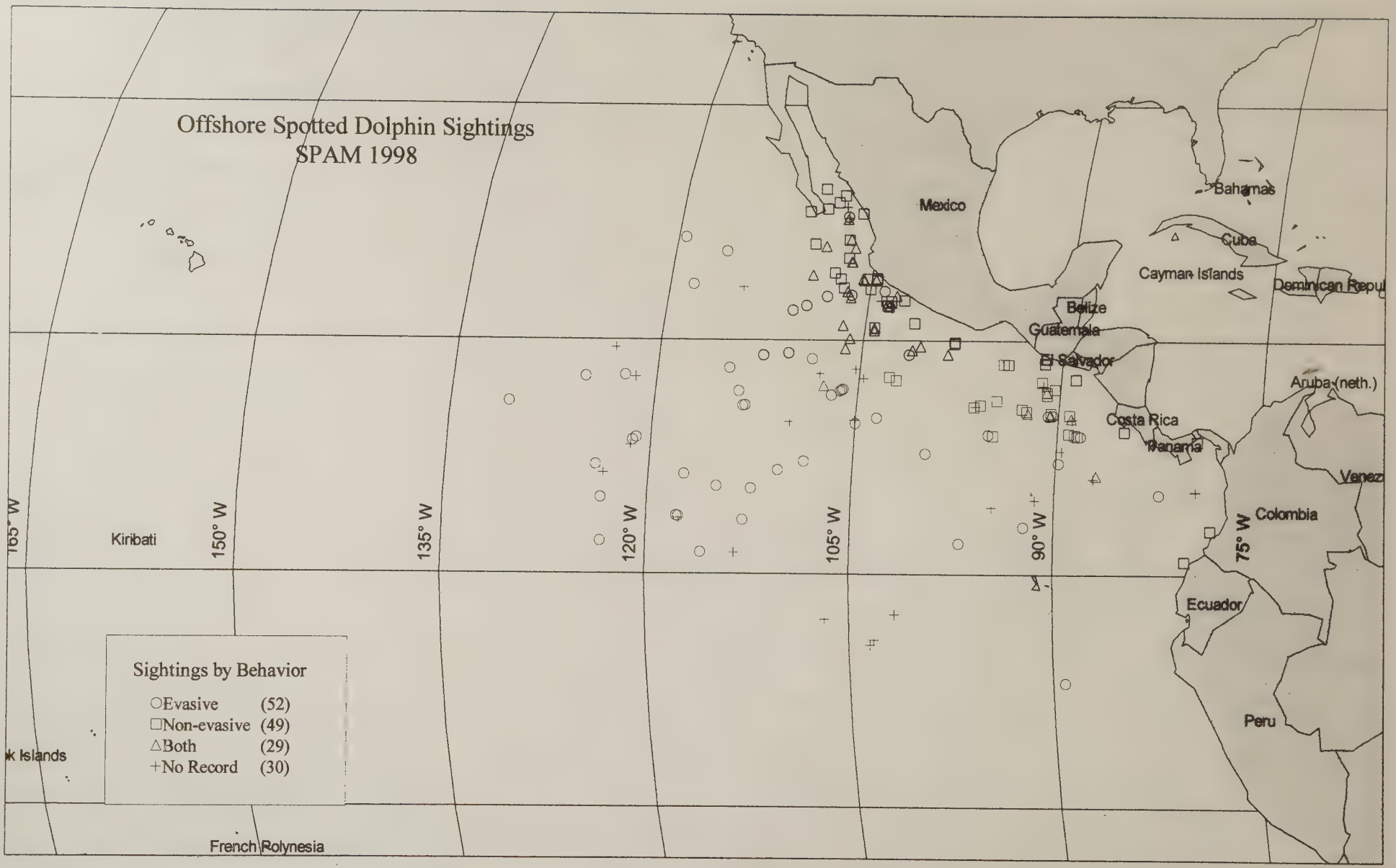


Figure 23. Offshore spotted dolphin sighitngs for SPAM (1998) plotted geographically by behavior.

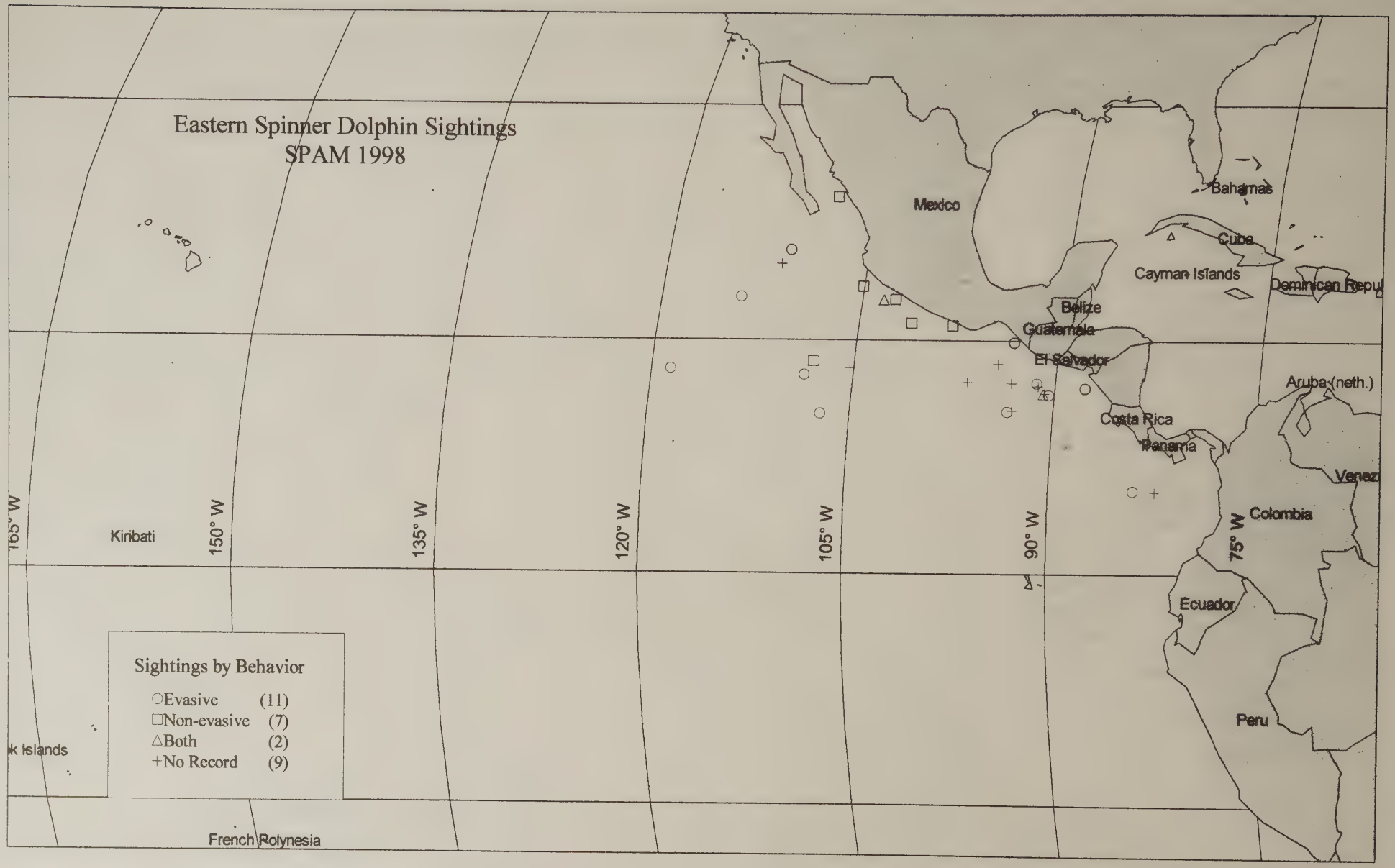


Figure 24. Eastern spinner dolphin sightings for SPAM (1998) plotted geographically by behavior.

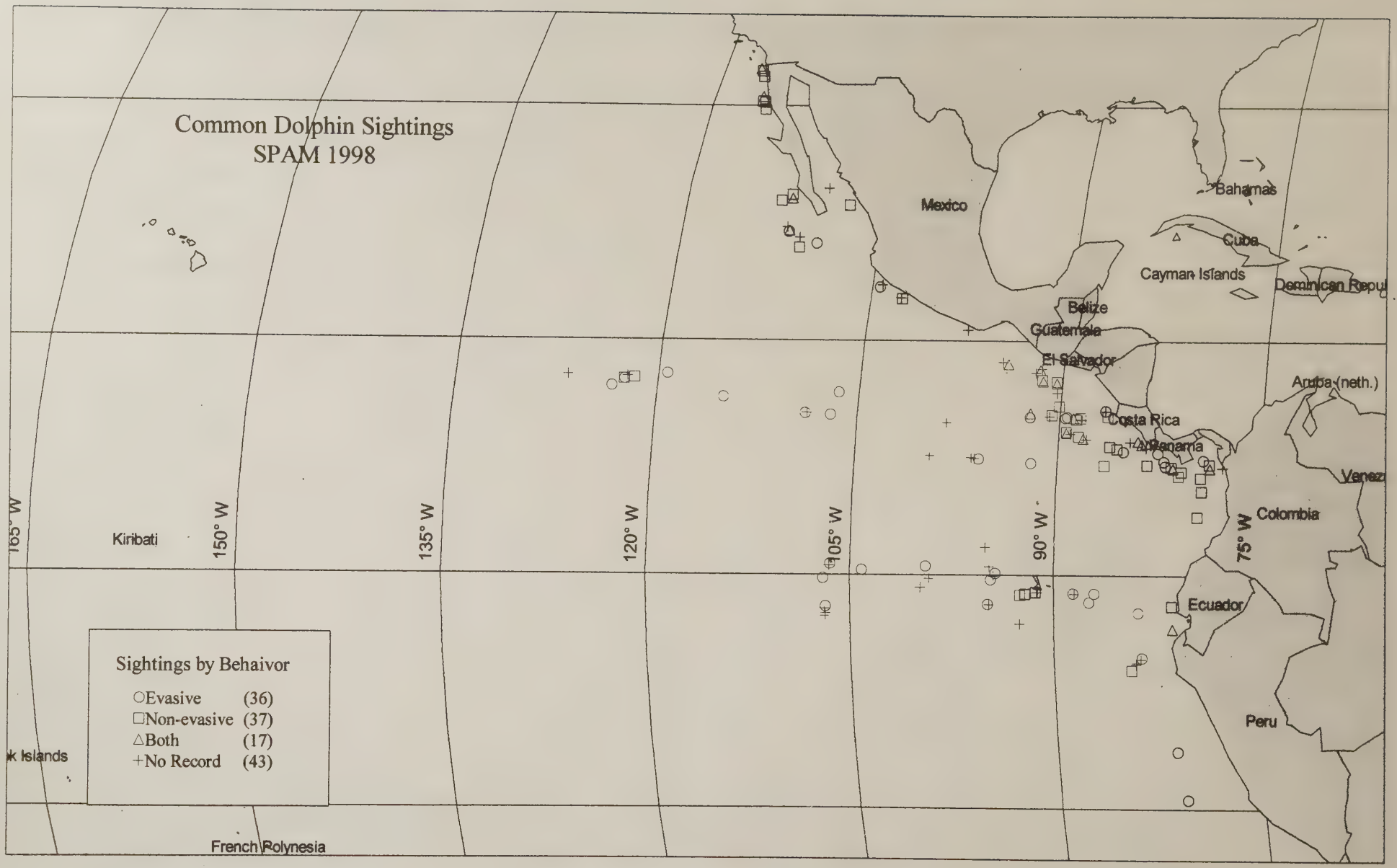


Figure 25. Common dolphin sightings for SPAM (1998) plotted geographically by behavior.

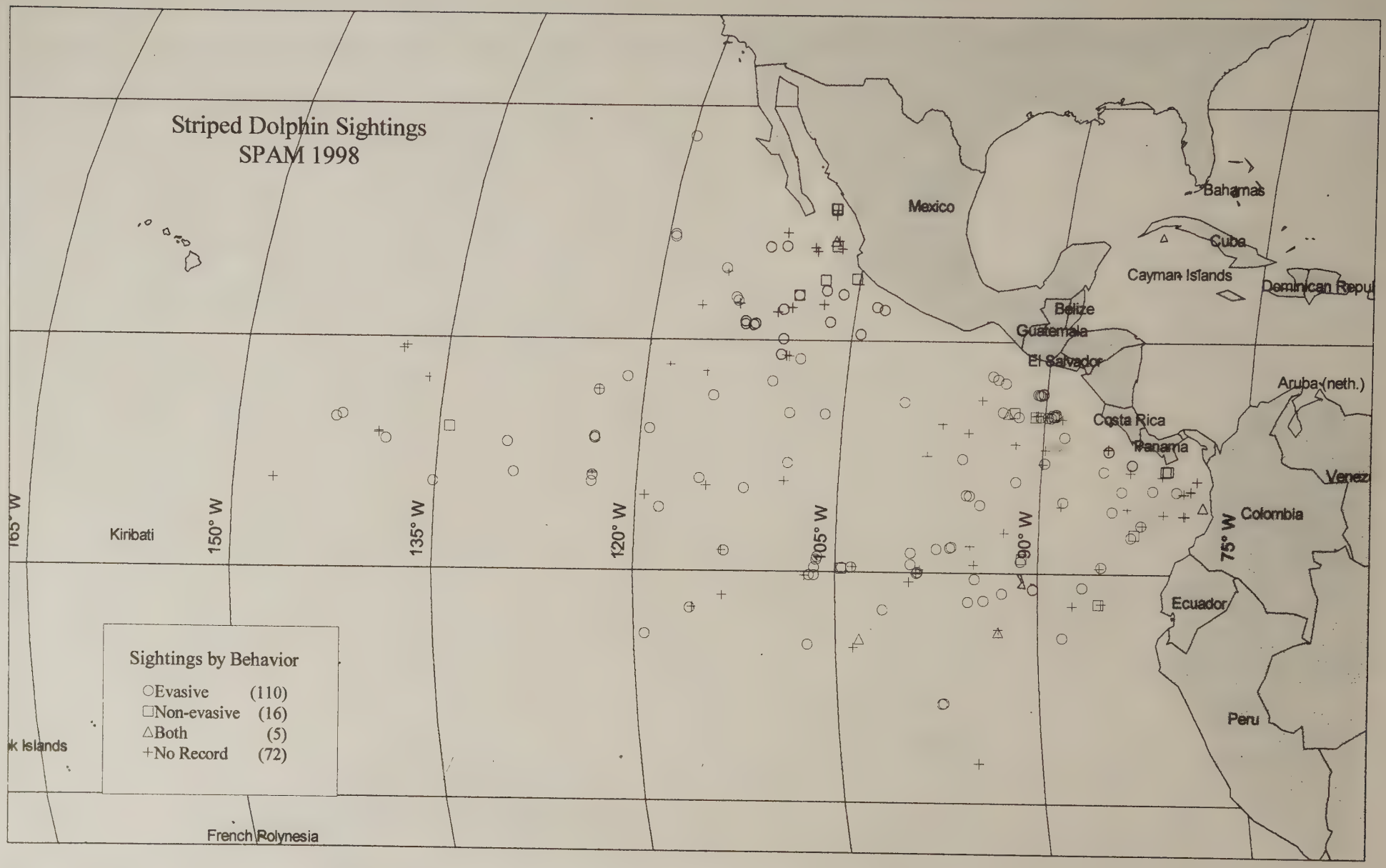


Figure 26. Striped dolphin sightings for SPAM (1998) plotted geographically by behavior.

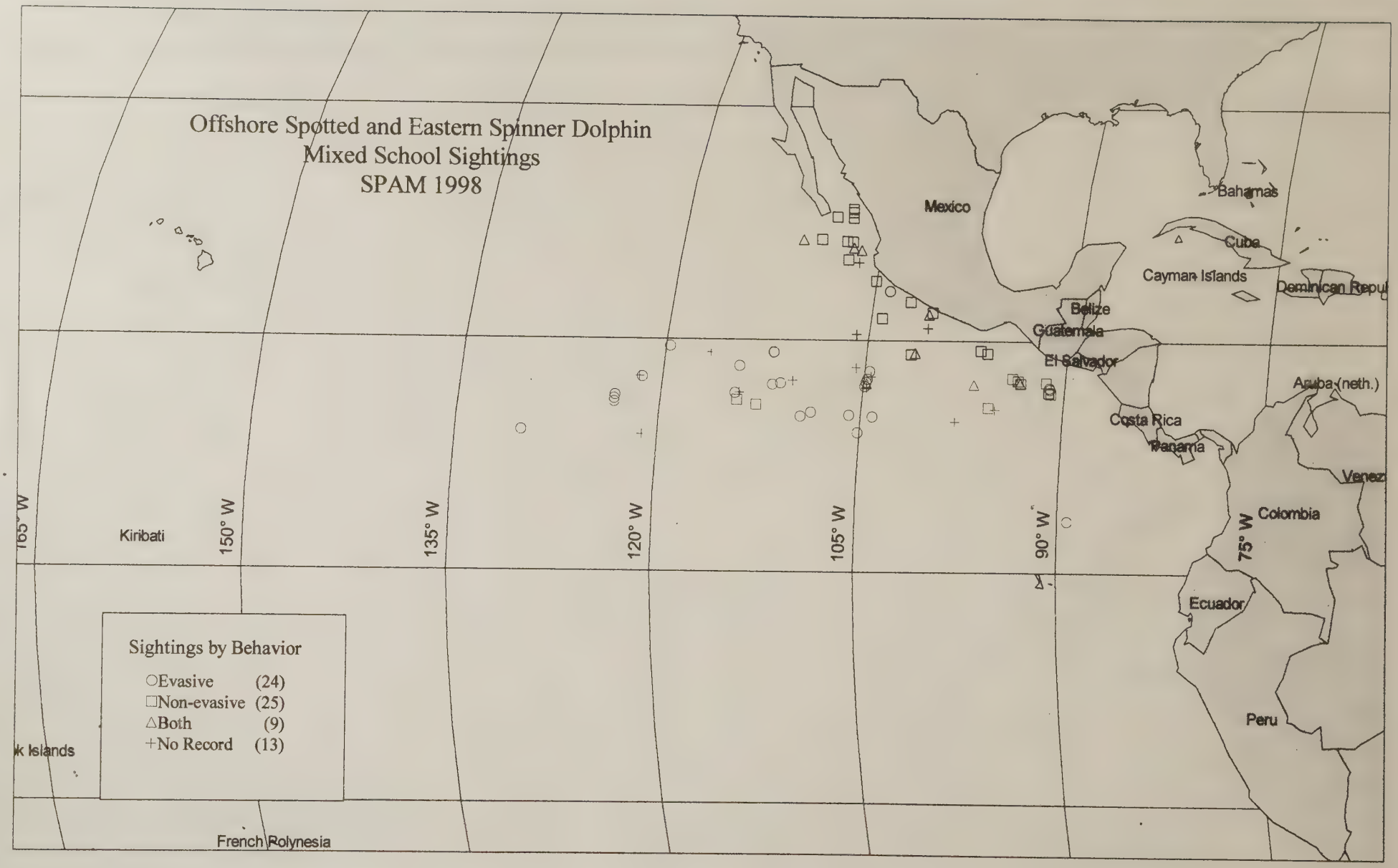


Figure 27. Offshore spotted and eastern spinner dolphin mixed school sightings for SPAM (1998) plotted geographically by behavior.

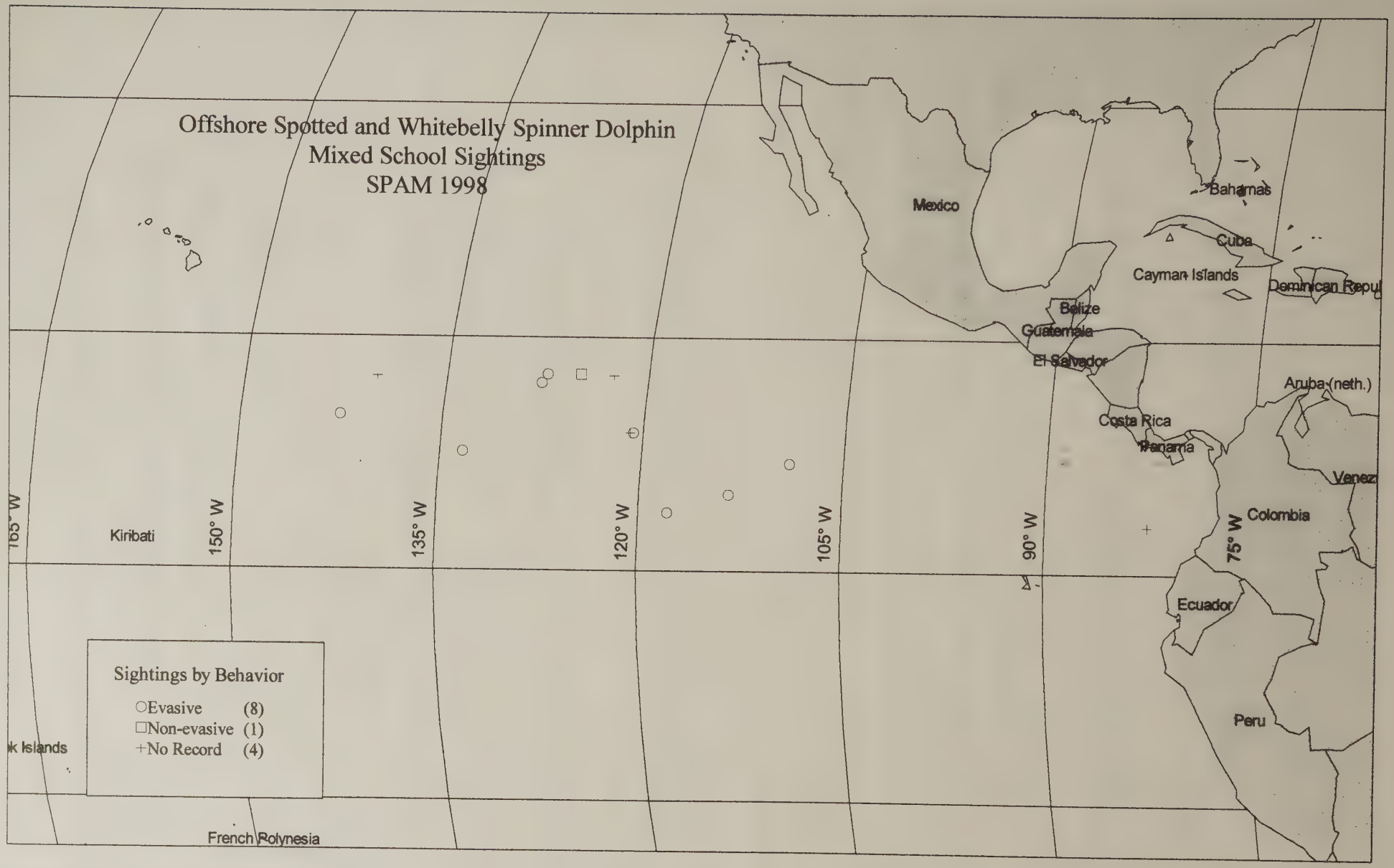


Figure 28. Offshore spotted and whitebelly spinner dolphin mixed school sightings for SPAM (1998) plotted geographically by behavior.

## APPENDIX 1

### Guide to ETP Dolphin Behaviors Recorded on Sighting Forms

I. Group Behavior

A. Traveling – counted when observer records "traveling," or when the individual or coordinated, polarized group is "moving" or "porpoising" in the same direction, at approximately three knots or greater. Aerial activity may also be noted.

Can be:

1. fast traveling – counted when observer describes rapid, directed swimming with many porpoising individuals. The school is highly polarized, or all individuals moving in the same direction.
2. moderate traveling – counted when observer describes a few of the individuals porpoising at medium speeds.
3. slow traveling – counted when observer describes few or no individuals porpoising at slow speeds, and/or the movement of the school is less direct and polarized.

B. Milling – counted when observer records "milling," or describes a non-polarized school remaining in the same general area; movement of individuals is characterized by frequent changes in direction over a small spatial scale, at speeds less than 2 knots. Aerial activity may also be noted.

II. Associations

A. Associated-swimming – counted when observer records individuals "swimming/diving," "feeding," or in a "feeding aggregation" in association with birds and/or tuna, or describes the school as moving slowly, diving deep, and spending less time at the surface; the school is not polarized. *Note: animals can be associated-swimming while traveling or milling.

III. Individual Behavior

A. Lob tailing – counted when observer records "lob tailing," or describes one or more individuals slapping the surface of the water with the tail flukes, creating splashes.

B. Aerial activity – counted when observer records one or more individuals "leaping," "spinning," "breaching," "tail walking," "roto-tailing," "head slapping," etc.

C. Porpoising – counted when observer records "porpoising," or describes smooth arching leaps clear out of the water while traveling; entry into the water is splashless and rostrum first.

D. Other – describe behavior in comments section.

IV. Behavior Relative to the Research Vessel

A. Approach the boat – counted when observer records that individual/s are "attracted" to the boat, or alter course to swim directly towards it to "approach," but do not stay to bowride.

B. Bow riding – counted when observer records "bow ride," or describes the individual diving and surfacing in the bow wave of the boat.

C. Wake riding – counted when observer records "wake ride," or describes the individual diving and surfacing in the wake of the boat.

D. Running from the boat – counted when the observer records that individuals "run from

the boat," or "up and run," or describes the animals swimming at high speeds directly away from the boat, changing direction and/or increasing speed to do so.

E. School splitting – counted when observer describes the school "splitting" or "breaking into subgroups." If recorded by the observer, the composition of the groups before and after the split is also noted. This is not applicable to animals clumped in subgroups that remain so throughout the observation.

1. If a school splits, the individuals/subgroups can:
   a. move off in different directions (scatter) – counted when the observer records that the individuals/subgroups "scatter," or "swim away in different directions."
   b. continue to move in the same direction – counted when observer describes the individuals/subgroups swimming off together.

2. The final composition of the subgroups can be either:
   a. mixed – different species in the same subgroup. Counted when observer records that subgroups are "mixed species."
   b. single species – subgroups are species-specific. Counted when observer records that subgroups are "single species," or "species-specific."

F. School coalescing – counted when observer describes that after initial sighting, a more scattered school (perhaps milling or associated w/birds and tuna) "coalesces," "tightens," or "closes ranks" to become more tightly aggregated, cohesive, and polarized.

G. Low swimming – counted when the observer describes the individuals as difficult to see, due to swimming "low in the water," with "only the dorsals or small patches of back" visible on the surface.

H. Other "evasive" behaviors – counted when observer records that the individuals "avoid the boat," "avoid the biopsy boats," "scatter," are "ship shy," make "frequent changes in direction," or "slink off," etc.

V. Spatial Distribution of Individuals

A. Tightly aggregated – counted when observer records that the animals are in a "tight group/formation," or describes that the school is easily discernible; the beginning and end are well defined.

B. Loosely aggregated – counted when observer records that the animals are "spread out over a wide area," or are "widely spaced," or describes that the school is difficult to discern; the beginning and end are not well defined. If animals are loosely aggregated, they can be distributed:

1. uniformly – counted when observer records that individuals are approximately "evenly spaced."
2. clumped – counted when the observer records the presence of "subgroups."

VI. Composition of Schools

A. The presence or absence of calves/juveniles in the school is counted when the observer records that they are visible.

B. The initial and final species composition of the school is counted if the observer records them.

## APPENDIX 2

### Additional Behavior Observations – Delphinids Only

Closest distance between dolphins and vessel: _____

In you estimation, when first observed,
Were the animals already reacting to the research vessel? Y N U O

I. Group Behavior

Behavior when first observed (circle all that apply):

| fast traveling | moderate traveling | slow traveling | milling | associated swimming | unknown | other |
|---|---|---|---|---|---|---|

Did the behavior change during observation? Y N U O

If the behavior changed, what did the behavior change to?

| fast traveling | moderate traveling | slow traveling | milling | associated swimming | unknown | other |
|---|---|---|---|---|---|---|

II. School Shape

Were individuals spaced: tight loose unknown other

If loose, were the individuals: uniform clumped unknown other

III. School Composition

Calves present? Y N U O

IV. Reaction to the Vessel

Approach the boat? Y N U O

Bow ride? Y N U O

Run from the boat? Y N U O

Low swimming? Y N U O

Did the school split? Y N U O

If yes, did the subgroups move off in different directions? Y N U O

If it's a mixed school, was the final subgroup composition: mixed single species unknown other

V. In your estimation, relative to the research vessel, was this school:

| evasive | non-evasive | both | cannot be determined | other |
|---|---|---|---|---|